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THE NEW YORK & NEW JERSEY BRIDGE CO. proposing to bridge the Hudson at New York has a valid charter until March 10, 1898, according to an opinion rendered by the Judge-Advocate-General of the War Department. The law required that actual work of construction should begin within one year from the date of approval of the location and general plans by the Secretary of War. This approval was obtained on March 13, 1896, and as no work had been done the question was raised as to the expiration of the charter. Now it seems that the law also required the submission of all the plans and specifications to the Secretary of War, and these were not submitted until March 10, 1897. Judge-Advocate Lieber now advises the Secretary of War that the charter is alive for a year from the latter date. The recent extension of city pier-head line reduces the necessary river span by 400 ft., and this will doubtless necessitate a change of plans, and the new conditions will doubtless be taken advantage of to still further prolong the life of the charter, before actual work must be commenced. The Chief of Engineers of the United States Army had previously delivered an opinion contrary to that of the Judge-Advocate-General, and advised that the War Department was only concerned with the general plans approved in 1896.

RECREATION PIERS ON THE WATER FRONT OF New York are the latest device to give the people of the crowded districts fresh air without going far from home. One such pier has just been completed at the foot of East Third St. It has a water frontage of 300 ft. and a depth of 60 ft., with a building covering nearly the whole of this area. The second story of this building is a pavilion devoted to the above purpose, while the first one, judging from an illustration in the New York "Tribune" of June 13, is used for shipping freight. Three additional piers have been provided for, all the work being done by the city Dock Department.

DUNKIRK HARBOR, N. Y., 40 miles west of Buffalo, is now being improved under the river and harbor act of June 3, 1896, appropriating $10,000 for the commencement of the work. A new survey of this harbor was made in 1894, under the direction of Major E. H. Ruffner, Corps of Engineers, U. S. A., and the project was favorably reported upon, at an estimated total cost of $408,250. The plans propose the completion of a breakwater by the addition of 310 and 560 ft. to its two arms, and the dredging an entrance and a harbor basin of 65 acres to a depth sufficient for vessels drawing 16 ft. Bids were advertised for in March of this year and the proposal of Edward G. Hingston, of Buffalo, was accepted for $321,386, for the whole work. Mr. Hingston is now at work under the direction of Major Thomas W. Symons, Engineer Corps, U. S. A., the successor of Major Ruffner.

THE TRANSATLANTIC RECORD TIME between Sandy Hook and Southampton has been lowered by the American line steamer "St. Louis," to 6 days, 9 hours and 23 minutes. The former record, 6 days, 10 hours and 55 minutes has been held by the "Fuerst Bismarck" since September 1893. The "St. Louis" cleared the Sandy Hook Lightship at 11.57 a. m., on June 23, and passed Hurst Castle, off Southampton, at 2.20 a. m. June 30. Had the time been taken when the steamer passed the Needles, the usual timing point, it would have been about six minutes earlier.

TRIPLE-EXPANSION SIDE-WHEEL ENGINES have been fitted to a number of steamers for river service by A. & J. Inglis, of Glasgow, Scotland. The cylinders are inclined, placed side by side, with the low pressure crank leading, and the valve gear is worked by eccentrics and the Gooch stationary link. All the cylinders have steam jackets. The high pressure cylinder has a piston valve, receiving steam in the inside, while double-ported slide valves are used for the intermediate and low-pressure cylinders. The following are the particulars of the side-wheel steamer "Paris," built by this firm for the Messageries Fluviales del Plata:

Length	292 ft.
Beam	36 "
Beam over paddle boxes	65 "
Depth	13 "
Cylinders, diameter	30, 49 and 75 ins.
" stroke	7 ft.
Boilers, single ended, number	4
" diameter and length	11 × 11¼ ft.
Furnaces, 8; diameter	3½ "
Grate area	140 sq. ft.
Heating surface	5,150 " "
Forced draft	Howden
Crankshaft, diameter	16½ ins.
Wheels (feathering), diameter over floats	21 ft.
" size of floats (8)	11½ × 4 "
" arms and floats	Steel
I. HP., maximum (32 revs.)	2,500
I. HP., on trial trip (32 revs.)	2,200
Speed on measured mile	16 knots

ARMOR PLATE AT $425 PER TON having been recommended by the Secretary of the Navy Long, the Senate Naval Committee has finally agreed to this sum. This committee, in the last Congress, fixed the maximum price per ton at $300 after an investigation into the subject, but the Bethlehem and Carnegie companies, the only makers of armor, refused to bid. Both Secretaries Herbert and Long recommended raising the price to $400, but this limit was also rejected by the above-named firms, and Secretary Long then suggested the compromise price of $425 per ton. This latter limit of price has now been inserted in the General Deficiency Bill, shortly to be reported to the Senate. The three battleships requiring this armor are rapidly approaching a stage where the armor is needed.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a trestle failure due to a washout at Missouri City, Mo., on the Wabash R. R. A fierce storm swelled the usually small stream which the trestle crossed into a torrent, and carried away a highway bridge further up the stream. When this struck the trestle it gave way. A farmer living near found the break and stood in the storm for an hour to signal the express. His efforts were unsuccessful, because the engineer failed to see his signal in the blinding storm. Excepting the engine and the two rear coaches, the whole train went to the bottom of the ravine. Seven men were killed and nineteen were injured.

A HEAD COLLISION occurred June 26 on the Cleveland, Akron & Columbus Ry., north of Millersburg, near Akron, O., resulting in the injury of seven persons. Through a misunderstanding of orders the first section of an excursion special ran into a regular Baltimore & Ohio train.

ANOTHER COLLISION happened at Woodbury, N. J., on the West Jersey and Seashore R. R., June 23, resulting in the injury of a number of persons. A Cape May express train stopped to cool a hot box and a following fast freight ran into the standing train. Fortunately nearly all the passengers had left the train while the hot box was being cooled. Newspaper reports ascribe the accident to want of care on the part of the express train crew in flagging.

THE BURSTING OF THE MAIN STEAM PIPE of the Pennsylvania R. R. ferryboat "St. Louis," in New York Harbor, on June 27, flooded the engine room with steam and severely scalded the engineer. The vessel is a new one and has been in service only a few months.

A BLAST WAS FIRED BY LIGHTNING at Rockland, Me., on June 28, killing one man and badly injuring two. Eight loaded holes were being connected for firing, when lightning struck the battery wire, thus prematurely firing the charges.

THE GRADE-CROSSING COLLISION at Valley Stream, (L. I.), N. Y., on the Long Island R. R., by which 5 persons were killed and 17 injured, by a train striking a tally-ho (Eng. News, June 3), has been passed upon by a coroner's jury, and their verdict is to the effect that the railway "was criminally responsible in not keeping in order the electric bell at said crossing." The case was referred to the Grand Jury.

A SERIOUS RAILWAY ACCIDENT occurred on the Galena Division of the Chicago & Northwestern Ry., 30 miles west of Chicago, about noon June 30, and resulted in the death of three persons and the injury of from 20 to 30 others. According to the press dispatches, the accident was a rear-end collision, between sections No. 4 and No. 5 of the Christian Endeavor Special, sent out from the Chicago & Northwestern Ry. station in nine sections, and carrying delegates from the Christian Endeavor Convention held in Chicago this week. Owing to the crush caused by the rush of delegates to return home, it is stated, that all schedules were abandoned, and trains were sent out as fast as filled. Section 4 of the special had stopped just out of West Chicago, when Section 5 crashed into it at great speed, wrecking the engine and driving the rear sleeping car of Section 4 into the second sleeper. Both cars were badly wrecked, but the most serious injury was to the passengers in the second sleeper. No reason is stated for the accident at the time of going to press. The Chicago & Northwestern Ry. has a block signal system from Chicago to West Chicago.

A NEW GRAVITY WATER SUPPLY FOR TROY, N. Y., has been recommended by Prof. Wm. G. Raymond, Engineer to the Water Commissioners. The water would be taken from streams known as the Tomhannock and Quackenkill, to the extent of 18,000,000 gallons per day at an estimated cost of $904,000. In connection with his report Professor Raymond points out that if the whole amount of water furnished in Troy was paid for at the present meter rates, the revenue would be increased from $97,000 to $165,000.

A CONTRACT FOR A 50-IN. STEEL CONDUIT, about 18,500 ft. long, for the water-works of Minneapolis, Minn., has been let to T. A. Gillespie & Co., of New York and Pittsburg, for $343,726. The lowest alternative bid for a 48-in. cast-iron pipe was over $100,000 higher. The detailed bids were published in our Construction News Supplement for June 17. Mr. F. W. Cappelen, M. Am. Soc. C. E., is city engineer of Minneapolis.

A VOTE ON MUNICIPAL OWNERSHIP OF WATER-works in Denver is recommended in a recent message of Mr. T. S. M'Murray, Mayor of that city. Denver has passed through a bitter rivalry between two water companies, resulting in consolidations, as all such attempts at forced competition between natural monopolies must. The people enjoyed practically free water for many months, but since consolidation they are being made to realize that those who dance must pay the fiddler. Recently there has been much bitter complaint regarding the highness of the rates, resulting finally in the passage of a city ordinance aiming to fix the rates at an average of those charged in Chicago, Cincinnati and St. Louis, as stipulated in the company's franchise. The company has given notice that it will not accept these rates and will shut off water from consumers who refuse to pay the charges established by the company. The city is taking legal steps to prevent such action.

THE MISSISSIPPI RIVER FLOODS COST the city of New Orleans $171,000, in protective work, according to the late report of the New Orleans Levee Board.

THE MISSISSIPPI FLOOD OF 1897.

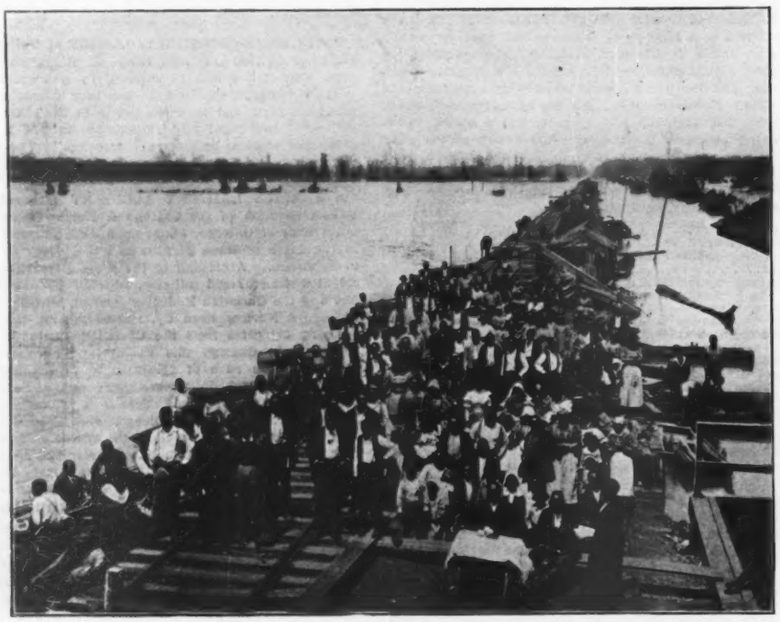
By William Starling,* M. Am. Soc. C. E.

(With two-page plate.)

Some persons regard the Mississippi as extending from Lake Itasca to the Gulf of Mexico, and consider the Ohio and Missouri as its tributaries. By those who dwell in the alluvial valley of the river, a very different view is taken. By them the term Mississippi River is applied only to the great trunk stream below Cairo, of which the Ohio, Upper Mississippi and Missouri are the constituents. In the early spring, the Mississippi, thus defined, is little else than the continuation of the Ohio; in summer it is composed of the three confluent streams in nearly equal parts, with considerable contributions from lower rivers.

The Sources of the Flood.

The flood of 1897 proceeded mostly from the Ohio and its affluents. Of the 1,570,000 cu. ft. per second or so, which passed Cairo at the time of maximum flood, about 1,200,000, or 76%, came from the Ohio; large contributions being derived from the Cumberland and Tennessee. Of the remainder, a considerable portion was due to the rivers which drain the northern slopes of the Ozack hills—the Osage, Gasconade and minor streams.



A CHURCH CONGREGATION DURING THE OVERFLOW.

Below Cairo there were moderate accessions from the St. Francis, White and Arkansas rivers —perhaps 200,000 cu. ft. per second in all, at the time of extreme high water. The discharge of these tributaries had been considerably greater at a time anterior to this.

While the Upper Mississippi and Missouri were not especially instrumental in bringing about the high stage at Cairo, they were very efficacious in prolonging it. As the Ohio slackened, they increased their supply of water until it amounted to about 45% of the discharge at Cairo, which had then diminished to about 1,400,000 cu. ft.

As compared with previous floods, the high water of 1897, at Cairo, ranks with the highest ever recorded. The extreme point reached was 51.6. This has been exceeded only three times. In 1882 the maximum reading was 51.83; in 1883, 52.17; in 1884, 51.79. In 1815 the river is said to have about reached the stage of the present year, 51.6. The floods of 1867 and 1886 mounted as high as 51.0; that of 1862 to 50.8. These are the only instances in which the mark of 50 ft. is known to have been exceeded. The floods of 1786 and 1844 were unprecedentedly high at St. Louis, but are not known to have reached any great altitude at Cairo.

While in extreme height the flood of 1897 was exceeded by those of the great cycle of 1882-4, yet it stood above the 50-ft. mark longer than any of them, namely for 19 days, as compared with 9 days in 1882, 14 in 1883, and 13 in 1884. The average stage for that period was 50.9. For the 19 highest days of 1882 the average stage was 49.8; in 1883, 50.6; in 1884, 50.5. When it is considered that duration of a flood is of as much importance as height the flood of the present year may be fairly classed with the greatest on record.

Below Cairo, the Arkansas was at less than a moderate stage at the culmination of the flood of the Mississippi, standing then at a gage-height (average of several days) of about 12 ft. The White River, however, was decidedly high, standing at an average of about 25 ft. on the Jacksonport gage. Both had been considerably higher, so it is probable that they discharged into the Mississippi, through their common basin, very nearly the quantities corresponding to these heights, namely about 160,000 cu. ft. per second. The St. Francis was so much affected by overflow water that its condition can only be inferred. It runs nearly parallel to the White River, and participates generally in the movements of the latter. It has a much smaller drainage basin, however, less than one-third as great, and its discharge was probably not more than about 40,000. The total discharge then, below the mouths of all these tributaries, allowing for reservoir-effect between Cairo and Arkansas City was probably about 1,740,000. This is very nearly the estimate made for the discharge of 1882.* No estimate has ever been made of the discharge of either 1883 or 1884, it being tacitly assumed that they were about equal to that of 1882.

Effect of New Levees Upon the Flood Height.

It is not only the magnitude of the flood of 1897 which has made it of surpassing importance to the engineers of the Mississippi service. The widespread damage which it has wrought, while great, is yet not without a parallel. Its principal interest to the engineer is due to the experience which has been derived from the wholesale closure of unleveed tracts and the extraordinary elevation of its high-water line consequent thereon.

There are two of the great basins into which the Mississippi Valley is divided which have only recently been protected to any extent, by levees. These are the St. Francis and the White River basins. The former was closed during the last three years, or since the flood of 1893, to a distance, measured along the river, of about 120 miles. There still remains a gap of about 100 miles. The White River basin has been undergoing a gradual process of closure for several years. In 1893 there was a gap of about 15 miles, extending between points 330 and 360 miles, respectively, by river, below Cairo. In 1896 this gap was closed and the line of levee was made continuous from the hills at Helena to a point 8 miles above the mouth of White River.

It is to the building of these lines and to the maintenance of the lines previously existing until a late period of the flood that the unparalleled stages attained by the water have been due.

Storms Which Preceded the Flood.

Probably it will conduce to the understanding of the phenomena of Mississippi floods to follow the progress of this one. It began early in February, with rain and snow in the Ohio and Central valleys, which, aided by what little snow there was lying on the ground (an inch or so) brought the Ohio to a stage of 44.4 at Cincinnati. There were moderate rises in the Cumberland and Tennessee, and a fair stage at St. Louis. The Cairo gage rose to 34.7, and had suffered only a slight decline when it was caught by another freshet. From the 20th to the 24th of February, heavy rainfall occurred in the Ohio Valley, bringing the Cincinnati gage to the extraordinary height of 61.1. At the same time, sharp freshets took place in the Cumberland and Tennessee. The flood was mostly a "head rise," however, and, despite the high stage at Cincinnati, would have brought the Cairo gage only to about 44 feet, had it not been reinforced by a sudden accession from St. Louis, and from the minor streams in the Central Valley, due to very heavy rains. By these means the river at Cairo attained a height of 48.6 on March 11.

The rainfall just mentioned was principally caused by the passage over the lake region of a cyclonic storm, which precipitated a vast quantity of water over the states of Arkansas, Missouri, Illinois, Indiana, Ohio, Kentucky and Tennessee, on the 5th and 6th of March. In many localities the rain was exceedingly heavy. Numerous "cloudbursts" were reported, and much damage was caused by washouts and the like. Five inches of rain fell at Cincinnati, and more than 3 ins. at Indianapolis, St. Louis and other points. This was rapidly succeeded by other storms. In fact there was hardly a day without rain, from the 2d to the 23d of March. The total precipitation during the month, in the Central Valley, was about 10 ins.* The effect of this constant downpour was to produce a stage at Cincinnati, on the 12th, of 50.1; at Chattanooga, on the 15th, of 37.9; at Nashville, on the 20th, of 48.6, and at St. Louis, on the 29th, of 23.2. The resulting gage-height attained at Cairo was 51.6, on the 25th and 27th.

It will be perceived that no very high stages were reached at any of the principal stations. At each, the record of this year has often been exceeded. At Cincinnati the river has been known to mount as high as 71.1; at Nashville, 55.3; at Chattanooga, 54; at St. Louis, 41.4. It was the duration and persistency of the floods in the several tributaries, rather than their height, which caused the waters of the Mississippi to assume such formidable proportions.

It was not at first evident that a great flood was impending. Nevertheless, it was perceived that a stage of 48 or 49 ft. at Cairo was in sight, and that was enough to put the engineers and river people on their guard. Parties were set to work to repair the places in the levees suspected to be weak or known to be low. As the situation developed itself, exertions were redoubled, and as the water mounted up with unexampled rapidity, very large forces were employed.

Evidence of Channel Erosion Between Levees.

It was well known to the engineers engaged in the levee service on either side of the river that a flood like 1882, if entirely confined, would go over the tops of their embankments as at present constructed; unless, indeed, the higher velocity de-

* Chief Engineer Mississippi Levee District, Greenville, Miss.

* Trans. Am. Soc. C. E., Vol. XXXV., p. 490.

*See the Precipitation Chart for March, herewith shown.

veloped by the confined waters should scour out the channel to a greater depth, and thus offset, wholly or partially, the additional elevation of the water surface. That this consequence would ensue was earnestly contended by the late Mr. Eads, with all his wonted vigor, and it has been maintained by many engineers of ability up to this day. There are some circumstances that favor such a conclusion. In certain reaches of the river, while they were still unprotected by levees, there used to be a very large escape of water over the banks. It was found that in such situations the bed of the river had actually suffered a considerable elevation. This deterioration or filling up of the channel was naturally ascribed to the loss of volume due to the escape by overflow, and it was contended that when the mass of water formerly lost was restored to the river by confinement between levees, the bottom would scour out again. This reasoning seems to be sound, and levee engineers have been anxiously waiting for evidences of such a deepening and of the lowering of the high water plane which would give the most convincing proof of it and which would be its most desirable result.

The confinement of the water by levees has been going on steadily ever since 1882. In that year extensive and long-continued discharge measurements were made, from which have been deduced, with a reasonable approach to accuracy, the heights to which subsequent floods of given magnitudes would ascend.* Thus it was thought a flood with a discharge of 1,500,000 cu. ft. per second, closely confined, should pass Lake Providence at a stage of something like 44 ft. on the gage of that station. If then, heights attained by subsequent floods should prove to be less than the experience of 1882 had indicated as probable, it would be evidence, more or less trustworthy, of a lowering of the high-water plane.

Up to this year observation had not shown satisfactory proof of such a lowering. There was proof, indeed, of scour; but the scour had seemed to turn itself rather against the banks than against the bottom, making the channel wider but no deeper. Levee engineers, while dreading the effects of a great flood upon their embankments, yet awaited, with deep interest, the evidence which would be afforded by the crucial test of a great flood, more closely confined than ever before. They were, therefore, on the alert to observe every feature of the impending high water.

Very diverse views have been entertained and expressed as to the policy of closing such basins as those of the St. Francis and White Rivers, and as to the effect of such closures on the high water line. Generally, by those most nearly concerned, it has been considered that the probable consequences would be an increased height of the flood line. It was contended by some engineers of distinction that the proper method of reducing flood-heights was to build up the levees in such situations, confine the waters and thus enable the river to adapt its bed to the increased volume. It was said that "the most frequent or habitually recurring maximum probably fixes the dimensions of the channel," and that if the White River and St. Francis fronts were closed by levees, the height reached at Helena in 1886 (48.1) would probably not be much exceeded by any such floods as had been heretofore experienced.†

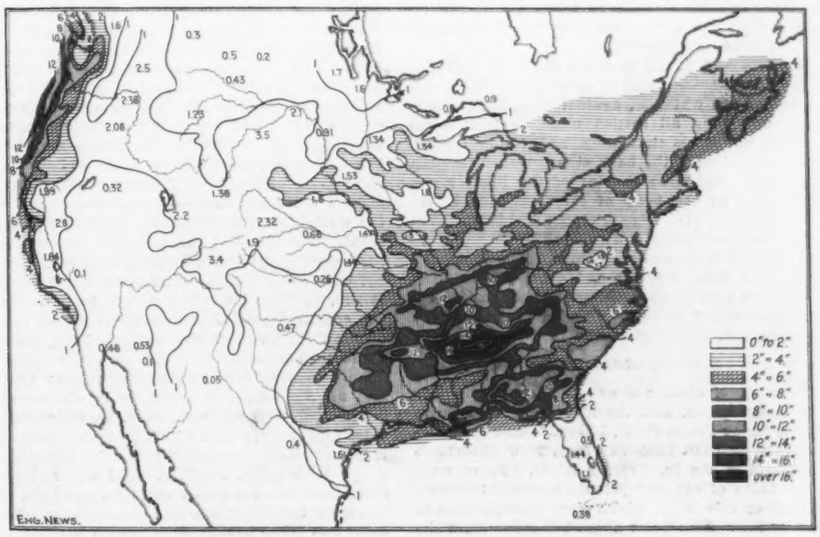
The engineers charged with the maintenance of levees would have been very glad to hold to this comfortable doctrine if they could. As a matter of fact, however, it appeared that each successive reclamation had been followed by a higher flood-line. In the words of General Comstock, there were no data for determining either the amount of such lowering or the time required for it. They, therefore, looked with grave apprehension for the consequences of a great flood in the imperfect condition of their earthen walls. These apprehensions were not only felt, but expressed. In 1894 the writer, in a published report to the Board of Mississippi Levee Commissioners, declared his belief that the levees of the Lower Yazoo District would have to be 3 ft. higher to hold a flood like 1882, and in 1895 he showed,* to his own satisfaction at least, that the flood of 1882, if confined, would have gone to 55.8 at Arkansas City. This means 2.5 ft. above the top of the levee at that point, and about 3.5 above the top of the levee at Greenville. It means 4 ft. higher than the actual high water of 1897, and is very nearly what, it is estimated, would have been reached this year if the levees had not broken. Mr. Dabney, Chief Engineer of the Upper Yazoo District, thought the conclusion rather over than under the truth. Captain Townsend, the engineer officer in charge of work for the United States, by a different method, arrived at substantially the same results. It may be imagined then with what interest, as well as anxiety, the flood plainly in view was awaited

Preparatory Work, Strengthening the Levees.

The rise was rapid and steady, and prolonged to a very high stage at a rate which was beyond all precedent. At Helena the rate was 0.7 ft. a day for 23 days; at Arkansas City, 0.6 ft. a day for 26 days; at Greenville, 0.6 for 27 days, and, doubtless, the rise would have continued, with some dimunition in the rate, for several days longer had no breaks occurred. At Helena it would have continued for 2 days more at a rate of 0.6, and then for 15 days at a mean rate of 0.2. At Arkansas City at 0.5 for 4 days and nearly 0.3 for 15; at Greenville, nearly the same. Formerly, when the bank-full stage was reached, and the water began to flow over the banks of the unleveed tracts, the rate of rise decreased rapidly. With the successive stages of progress in the building of levees, the rate of rise which had prevailed while the river was within its banks was prolonged further and further to high stages.

The first and most pressing cause of anxiety to the engineers was lest their levees should be actually overtopped. In the several districts the grades had been changed many times, as the increased height of the floods and the varying circumstances prescribed. In the Lower Yazoo District the grade had been successively 2 ft. above the high water of 1882, 3 ft. above the same, 3 ft. above 1886, 5 ft. above 1888, potential high water of 1890 (that is, what, it was supposed, would have been the high water of that year if there had been no crevasses), 1 ft. above potential high water of 1890, 4 ft. above actual high water of 1891, 3 ft. above the highest water, whatever that might be (at some places it was 1890, at others 1892 or 1893), and 4 and 5 ft. above the highest water; the two last being of very recent date, and extending over only a small part of the district. A large portion of the line was old levee, most of it built before the war, but raised and enlarged at different times as standards changed. In short, the line was patchwork. There was considerable stretches of levee which did not hold up to nominal grade. The plastic blue or black clay of the Mississippi Valley, commonly called "buck-shot earth," while making an excellent bank for turning water, yet has this defect; that it is forever settling. Probably this tendency is increased by the periodical saturation which the levees get when the water stands against them. Although they are not habitually used as roadways, and wheeled vehicles are not allowed upon them, there is yet a good deal of pedestrian and horseback travel upon them; and, as they are not macadamized or protected in any way, they are degraded, too, from this cause. In some situations the foundation or bed itself of the levee is liable to settle, and it is suspected by some engineers that this evil is more general than is commonly supposed.

For these reasons there were considerable inequalities in the grade. The conspicuously low places were promptly taken in hand at the first intimation of a serious flood, and the minor deficiencies as occasion demanded. It was soon very evident that there was water enough to go 3 ft. or more over the tops of most of the levees if everything should hold. It was manifestly impossible to raise several hundred miles of embankment to such a height in two or three weeks even if money had been forthcoming; and if this had been possible, it was known that the cross-section was not strong enough to stand so great a head of water. It was clear, therefore, that somebody's levees had to break or be overtopped, which last incident inevitably leads to breaking. All that was left then was for each man to make the best fight he could for his own line, and see that the break should not occur in his territory if he could help it.



TOTAL RAINFALL FOR THE MONTH OF MARCH, 1897.

While the interests of the right and left sides of the river are directly antagonistic in these struggles for existence, yet there is no unkindly feeling between the participants. If the engineer in charge of the Arkansas or Louisiana side wants wheelbarrows or sacks, his Mississippi brother will lend them to him if he can spare them. The two frequently meet on steamboats or elsewhere and compare notes, discussing their prospects and apprehensions with great candor. Rumors are often circulated of preparations made by unscrupulous characters on the one side or the other, to cut or blow up the levees of their opposite neighbors, but the writer has yet to learn of a single instance in which these reports have been shown to rest upon any solid or even plausible ground. They belong to the class of "high-water lies."

The quickest and cheapest way of "topping" levees, that is, of raising them without adding to the base, is by means of planking set on edge and backed with earth. Posts are driven into the levee near the front edge of the crown, and one, two or three tiers of horizontal plank nailed to them, as neatly and closely as may be. Earth is then thrown against the fence or wall thus

*"The Discharge of the Mississippi River," in Trans. Am. Soc. C. E. for November, 1895.

†See Colonel Suter's paper on "Effects of Recent Levee Construction," etc., in Report of Mississippi River Commission for 1895, p. 3649.

*Trans. Am. Soc. C. E., Vol. XXXV., p. 490.

formed, in such quantity as may be sufficient or practicable. The earth should not be obtained from the body of the levee if it can be helped. Most often this expedient has to be resorted to sooner or later, especially when the flood is advancing with great rapidity. In low or badly-drained places, the seep water and rain water accumulate on the land side of the levee in such quantity as to cut off all access to material beyond the base, and even where it can be obtained, it is slow work wheeling it to the top of the embankment. By "robbing" the levee, miles can be thrown up in a day with no other implement than a shovel. It is not so hazardous a practice as might be supposed, unless the levee is exposed to winds; for the material is taken from the top of the bank, where there is always superfluous strength. If the foreshore is bare of timber, however, and the levee faces prevailing winds, it is very dangerous to denude the embankment of its sod, as the waves, dashing over the topping, will soon cut gullies in the back slope, and, in case of heavy gales, may easily wash it in two.

In the district of which the writer has charge, some 90 miles of levee were topped, and about 1,000,000 ft. of lumber used in the process. Preparations had been made to top most of the remainder of the levee, when crevasses rendered further work unnecessary.

Deficiency of grade was not the only difficulty which the engineers had to encounter. Three new levees had the water let against them for the first time, and they all settled more or less; some portions so much that they had to be topped. Sloughs or slips of the back slope, "boils" through the natural soil near the toe of the inner slope, subsidences in the body of the levee due to internal cavities, etc., were frequent incidents. Protection against wind storms was a very important item of high-water expense. About 725,000 sacks were used, for this and other purposes, at an average cost of about 5 cts. apiece, besides labor in filling and placing. Lumber cost about $14 per thousand, delivered at the landings.

Breaking of the Levees.

The work of closing the St. Francis Basin had only lately begun, and the levees extended down only as far as Pecan Point, 196 miles below Cairo—rather more than half way from New Madrid to the mouth of the St. Francis River. There were the remains of old and private systems in existence along this front, which were incorporated in the new line. At a point about ten miles from the lower end of the system, as now constituted, at Nodena, in Arkansas, the first crevasse occurred, on the 14th of March, soon followed by others in the same vicinity. From its situation, so near the lower extremity of the line, the damage done by these breaks was mostly local, the only effect being to extend the area of the overflow, which "backed up" around the end of the levee system, and was limited in its progress up-stream by the slope of the basin, which is about 1 ft. to the mile. Probably some 2,000 square miles of the 6,000 in the basin west of the New Madrid ridge were thus covered with water. The crevasses were all in old levees. The condition of the river below Helena was little affected by them.

The engineers of the Upper Yazoo District had apprehended a greatly increased elevation of the high-water line below Helena, as a consequence of the sudden closure of the gap in the line of the White River front. Their appprehensions were speedily justified. On the 19th of March, the river at Helena being 0.3 ft. below the high water of 1893, the gage at Sunflower Landing, opposite the closed gap, stood 2.8 ft. above the same high water, which was, at this point, the highest known. The effect of the closure, then, was to raise the water-line 3.1 ft. As the river afterwards rose 4.2 ft. at Helena, the gage at Sunflower would undoubtedly have stool 7 ft. or more above all previous records. As the grade of the levees at these points was only 4 ft. above high water, it is evident that they would have been deeply submerged unless something had given way. On the 22d of March, however, a break occurred in the line of levee of the White River Basin, succeeded, on the next day, by others, which afforded local, but only local and temporary relief. The water which escaped through them soon returned at the mouth of the White River, 60 miles below, and as soon as the flow through the breaks adjusted itself, the river ceased to fall and began to rise again.

A few days previous to this time, on the 18th of March, a serious break occurred in the upper part of the St. Francis Basin, at Caruthersville, in Missouri, followed, at the interval of nearly a week, by two others. Hitherto only a small part of this large basin had been doing duty as a lateral reservoir. Now the whole area west of the New Madrid ridge fulfilled this purpose; the escaping water returning to the Mississippi at the mouth of the St. Francis River, just above Helena. It made its appearance there in about 12 days, manifesting itself by an increase in the rate of rise, which rapidly brought the river to its highest point, 51.85, 3.7 ft. above the highest previous record, and would have brought it still higher had it not been checked by crevasses in the vicinity.

On the 28th of March the river at Arkansas City had attained the height of 51.9, and at Greenville, 40 miles below, of 46.6. A large part of the line on the left bank had been topped, in anticipation of the great rise still to come, and the water was against the topping for many miles. The river was rising at Greenville at the rate of 0.4 ft. a day, and it was evident that the fight could not last much longer. On the night of the 28th a violent gale arose from the east, causing high waves on the rivers and lakes, and sweeping away the topping of the Deerfield levee, some 15 miles below Greenville, on the banks of Lake Lee, an "old river lake," formed by the cut-off of 1858, soon made a breach in the levee. The manner in which the water does its destructive work is well understood. The overfall causes rapid erosion on the back slope of the levee, forming deep gorges, which cut back to the crown, while the sides of the gorge fall in, and the levee is soon cut in two. One of the engravings on the inset sheet shows the fall over an old levee, as the water is being admitted against a new one.

On the next day another break was reported and on the next two more, all in old levees, at points remote from each other, showing that the older and weaker part of the line was about on a breaking strain everywhere. All the crevasses widened with great rapidity, until the fall of the river thus brought about and the rise of the back-water on the inside checked the velocity. Eventually two more breaks occurred on the same side of the river, one in the Upper Yazoo District, nearly opposite Helena, the other in the lower part of the Lower Yazoo. The back-water was already against the levee in the latter situation, so the crevasse did comparatively little damage. After the return of the flood waters at the mouth of the Yazoo, three breaks occurred in the Louisiana levees, and one more after the general recession of the water had begun.

The heights eventually attained at the principal stations below Cairo were:

		Since 1870.			
Memphis,	37.1	being 1.5	above	previous	record.
Helena,	51.85;	" 3.75	"	"	"
Mouth White R.,	52.4 ;	" 2.0	"	"	"
Arkansas City,	52.0 ;	" 1.7	"	"	"
Greenville,	46.65;	" 2.35	"	"	"
Lake Providence,	44.4 ;	" 2.5	"	"	"
Vicksburg,	52.5 ;	" 3.45	"	"	"
Natchez,	49.8 ;	" 1.2	"	"	"
Baton Rouge,	40.6 ;	" 2.15	"	"	"
New Orleans,	19.5 ;	" 1.6(?)	"	"	"

The heights which would have been reached, had it not been for the crevasses, have been estimated, with some probability, for a few stations. They do not differ materially from those estimated for a like condition of things in 1882.

Methods of Closing Crevasses.

In previous floods, often large sums have been spent in "securing," or "tying" the ends of crevasses, to keep them from widening. The practice, however, is falling into disuse. When a break first occurs the difference of head between the river water and the water on the land side is so great that the current is like a cataract, and no contrivances resting, as they all must rest, on friable soil, can check its destructive force for long, for it will itself be washed away. Tarpaulins have been proposed. The writer has tried tarpaulins a hundred feet long, weighted at the bottom with tons of iron, and has seen tarpaulins and iron swept away, with 200 ft. of the earth and levee on which they rested, in a single night. The most effective device known is that invented and executed in 1888 by Mr. H. M. Marshall, M. Am. Soc. C. E., of building spur-dikes, composed of brush and sacks, built at right angles to the broken levee, thus breaking up the destructive current which sweeps around the ends of the crevasse. Like all other devices, however, this fails in very rapid currents and very light soils. The ends of the dikes themselves are undermined, and eddies formed behind them, and frequently repeated attempts have to be made before the dike can be built that will stand. By that time, generally, the velocity has been so diminished that the task is greatly facilitated, and many an engineer, after finally accomplishing a successful work of this kind, has thought in his heart that the crevasse would have checked itself equally well without his assistance. Even if the ends can be held, so long as the current has a destructive strength it will scour the bottom, if not the sides, so the end of keeping down the discharge through the break is not accomplished. Usually now the dyke-method is employed only for special purposes, as to keep the crevasse from extending to sandy ground, or from invading a large and important levee. In 1892 and 1893 it was not used. This year it was used in two or three instances on the Mississippi side and not at all in Arkansas and Louisiana.

The closing of large crevasses, in the time to which it must be limited in order to be of any value, has hitherto baffled the engineers and everybody else. It is, as Dr. Johnson said, something rather to be wished for than attained. Pile dykes naturally suggest themselves. Steam pile drivers, however, are too slow and cumbrous to handle, especially in the very swift currents that prevail in the vicinity of breaks in levees. It has often been proposed to proceed by building from the two ends and meeting in the middle. This is the method mostly advocated by amateur crevasse-closers, and, indeed, some attempts have been made to carry such designs into execution. With large crevasses and in ordinary soil they have all been failures, as might have been expected, the scour as the two dikes approached each other becoming uncontrollable. The only plan that has ever succeeded at all is to build a skeleton dike around the whole break as rapidly as possible, reserving the filling-in to the end of the process, and then completing the closure, as it were, at one heat. Hand-piling alone has been found available for such a purpose, though it would seem that some form of light steam driver might be advantageously employed, perhaps worked by electric power, from a detached dynamo. There are two principal difficulties in the way. The first is to complete the dike before the piles scour out. The second is to find earth for the filling. Hitherto no means have been found for making the dike water-tight except with earth, and that is usually put into sacks, for economy, safety and ease of handling. Jointed sheet-piling has been proposed, but it is open to several objections. Unless it is very strong it will not stand the pressure to which it is subjected; unless it is driven very deep it is liable to "blow up" from beneath; it has little resisting strength of its own, and depends on the strength of the pile-dike which supports it. These conditions are hardly compatible with hand-driven piles.

Earth is one of the rarest of things in the neighborhood of crevasses. Generally none is to be obtained except from the part of the adjacent levee left above water. Now the number of sacks required for closure by the ordinary method is about twice the square of the depth of water per linear foot. For a levee 10 ft. high and for a dike 500 ft. long there will be required 100,000 sacks, or about 5,500 cu. yds. For a great crevasse like the "Stokes' break" of this year, a dike would be required about 20 ft. high and 4,000 ft. long. For such a work about 3,200,000 sacks would be needed, or nearly 180,000 cu. yds. Now, if the levee was low enough or weak enough to break, it is not likely that any earth can be spared from it.

In lower Louisiana, where the soil is strong and

the levees are not generally high, breaks frequently occur which widen very slowly. These can usually be closed in a day or two. In the larger levees and lighter soil, which prevail above Red River, the work of closing crevasses at high water has been generally abandoned, by common consent, as impracticable, under the limitations of time and expense which are imposed. It has often been attempted, however, with more or less success, after a fall had set in, when the current through the breaks had greatly diminished in violence, when a considerable portion of the old levee projected above water, or earth was accessible from other sources. The objection to such undertaking generally is that the river is apt to work faster than the engineer, and will "close the crevasse" by getting within its banks about the time that the last sack is being deposited in the dike.

This year, as the river was falling with discouraging slowness, alternating with an occasional stationary stage or slight rise, the levee engineers of the two Yazoo Districts considered it their duty to "stop off" the breaks, or to do something to lessen the flow through them. At the Flower Lake break, in the Upper District, Mr. A. L. Dabney, under the direction of Mr. T. G. Dabney, Chief Engineer, accomplished the remarkable feat of driving a pile-dike, 2,600 ft. long, with a maximum depth of 11 ft., and filling in with sacks, thus excluding the water completely. In the Lower District work was mostly confined to shutting off the flow through the deep channels, leaving the shallow places to be stopped by the fall of the river. In two cases timber-dikes were built entirely around the breaks. These were nothing more than windrows of trees, carefully thrown together, so that they might fall, one upon the other, and force the structure to the bottom. Wire cables were employed, when necessary, in rapid currents, to assist in holding the timber in place. No sacks were used, and there was no attempt to make the dike tight, the object being to reduce the cross-section somewhat, and at the same time deaden the current by opposing numerous obstacles to it, in accordance with Mr. McAlpine's maxim that "water abhors angles." In another instance, the Stop Landing crevasse, the engineer in charge, Mr. George C. Thomas, with great energy and ingenuity, succeeeded in building a brush-dike so close as to shut off a considerable percentage of water. Trees were felled, the tops cut off and the branches trimmed from the trunks. The latter were floated into place, laid parallel to the trace of the proposed dike and lodged against the stumps of the inner line of trees. A layer composed of tops and fine brush was then placed upon the layer of trunks or logs and perpendicular to it. On this another layer of logs was placed. As soon as standing room could be had men with heavy mauls drove a row of hand-piles as close as possible, to prevent scour under the bottom of the floating mass of brush and assist in the work of closure. Thus alternate layers of logs and brush were built, the logs being rolled on top of the brush by "parbuckling." Wire cables were stretched from tree to tree, when necessary, in many strands, to catch the floating brush and assist in holding it. At last the structure reached the bottom, the top of the dike projecting 2 or 3 ft. above the water. Originally it was not intended to do any more than this, but the work seemed so firm and strong that it was determined to make it entirely close. To this end the dike was strengthened, the piles braced to stumps behind and tied by wire cables to stumps in front. Sacks filled with earth were then thrown on the river side of the dike and the work made water-tight. The length of the dike was 1,200 ft., and the maximum depth 14 ft. The number of sacks used was less than 20,000; the timber and brush doing most of the work. The time occupied was 20 days.

At the Deerfield and Promised Land breaks the deep channels were stopped off by dikes of hand-driven piles, brush and sacks, built in the usual way. It is believed that the use of brush in conjunction with piles is an improvement. It is an innovation upon the Louisiana or Creole plan. It is used in the last stage of closing, before throwing in the sacks. It immediately shuts off overfall, gives bond to the work and economizes earth. It was used by Mr. B. B. Gordon at Promised Land with great success. Length of dike, 600 ft. Maximum depth, 10 ft. At Deerfield, Mr. G. G. Smith used hand-driven sheet-piling instead of brush, which was not to be had conveniently. The work was completed by sacking. The length of dike was 820 ft.; maximum depth, 7.5 ft.

The most recent and most remarkable work of crevasse-closing, however, was that just completed at the Conrad Break, in Louisiana, about 6 miles below Baton Rouge. The opening was 246 ft. wide. The dike around it was about 450 ft. long. During the process of driving, considerable scour took place near the northern end of the dike, and before its completion the depth had increased, in one place, to 24 ft. For 100 ft. or so, the average depth was 20 ft. The break was successfully closed on June 7, after 7 days' work. About 900 men were employed, and about 100,000 sacks were used. The piles were 4 × 4-in. scantling. The dike was built under the foremanship of bridge gangs from the Yazoo and the Mississippi Valley Ry., under the Superintendent of the Orleans Division, Mr. A. J. Greif, who had the direction and the active charge of the whole work. The piles were driven by what the bridge men call a "dolly," that is, a heavy beam supported at one end by a carpenter's horse or trestle, while the other is raised by hand-power and let fall upon the head of the pile, like a trip-hammer. It was worked by 10 or 12 men. The longest piles were 35 ft. In the deep water there were 17 rows of piling. The whole breadth of the dike, after its completion, was first floored over with sacks, and then successive tiers laid on, battering to the front, so that the overpour always fell on a cushion of sacks. The latter were brought a distance of 6 miles by barges and tugs. The work was carried on night and day. "Wells" lights and electric lights from the steamboats were used at night. The remains of an old levee behind the break, and the natural surface of the ground formed a basin of water behind the dike. Owing to this there was not, therefore, the full head of water against the dike after closure that the depth would indicate. The cost of the work, it was thought, would be about $25,000. A photograph on the inset sheet shows the dike under construction.

For the depth of water in which the dike was constructed and for rapidity and certainty of execution, this work is without a precedent in the rather meagre annals of crevasse-closing.

Popular "Solutions of the Mississippi Problem."

During and after each high-water season, especially if it be attended by signal disaster, the newspapers teem with articles on the "Mississippi Problem." As a general rule, these productions are distinguished, not so much for lack of ability as for lack of knowledge. Usually, the writers have not taken the trouble to inform themselves upon the most elementary facts and principles involved in the discussion. Those who have never seen the patient are most dogmatic in prescribing the treatment to be given him. It would seem that all the cranks and wiseacres in the United States had entered into a conspiracy to monopolize the newspapers, or else that there were no sensible men who knew or cared anything about the matter. Iron levees are proposed, wooden levees, stone levees, cement levees, brick levees, glass levees, paper levees. Instead of longitudinal dikes, one man would run cross-levees from the river to the hills, so as to build up the lowlands by deposit of silt. Another would cut cross-canals for the same purpose. Another would bore artesian wells in the bottom of the river to let the water out. Another would bore wells too, but with just the opposite intention, namely, to let in the water, and help to scour out the bottom. Another would divert the Tennessee into the Warrior, the Arkansas into the Ouachita, the Red River into the Sabine, and the Yazoo into the Pearl. As to the methods of controlling the channel, they are as many as the writers who propose them. Each man takes up the subject for the first time, evidently supposing that nobody has thought about it except himself.

The Mississippi problem is not the only topic which suffers from unskilful handling. The men who discuss it are the ones who speak with equal confidence on the tariff, the currency, or foreign policy. In such a hubbub, thoughtful and well-informed men do not care to raise their voices. They will speak at the proper time.

The levee question is not always discussed with candor or good temper. Very foolish and groundless assertions are made with the utmost assurance, and frequently the advocates of the levee system are charged with interested and sinister motives. It is difficult to see why this element of bitterness should be injected into the discussion. Levee engineers are not at all bigoted on the subject. They would gladly welcome any plan which holds out a fair promise of relief from the monotonous grind of piling earth on earth. Whatever method be adopted the aid of engineering science will have to be called in, and probably the very men who are now building levees would be employed if it were deemed best to substitute for the latter outlets, cut-offs or reservoirs. Either of these would afford infinitely pleasanter, more varied and more improving work than levee-building. It is sometimes asserted that it is fear of running counter to public opinion which keeps the engineers of the Mississippi service so obstinately attached to the levees. This is another misapprehension. It is the engineers who have built up public opinion in the Mississippi Valley on the subject of the improvement of the river. To a man of ability and strength there is a charm in being in the minority; and there is a far greater chance for distinction than in being one of the majority, to be overshadowed by the recognized and long-established leaders. Therefore, if there were good grounds for advocating other systems, there would not be lacking able men in their support.

The first thing to be borne in mind is that the Mississippi is a stream of very unstable and changeable bed, whose waters are highly charged with silt. By keeping this constantly in mind all things become clear. If it be lost sight of for a single moment, confusion and error occur.

Besides levees, several plans have been proposed for the reclamation of the alluvial lands of the Mississippi. They cannot be discussed here, but may be alluded to briefly. The principal are: reservoirs at the headwaters, cut-offs, outlets and the diversion of tributaries. Most of these have been very imperfectly examined. Very few details have been gone into, and no close estimates submitted.

Storage Reservoirs.

The plan of reservoirs would seem, on a casual inspection, to be unobjectionable in principle; that is, it would work no detriment to the channel and would not disturb existing conditions. Some of the drawbacks to have been enumerated by Humphreys and Abbot. Its application is very limited, and it would seem that its expense would be very great. It was estimated by Colonel Eliet, the great advocate of reservoirs 45 years ago, that to reduce the floods of the Mississippi 1 ft., for a period of 2 months, 9 reservoirs would be required, each of a depth of 110 ft. and an area of 7 square miles. This calculation was made on the supposition that the abstraction of 35,000 cu. ft. per second, near flood height would reduce the water-level by 1 ft. Now, later researches show that 50,000 instead of 35,000 cu. ft. per second would have to be withdrawn to produce this effect. Instead of 9 reservoirs there would have to be 13. As an example of such a work the Quaker Bridge dam will create a lake about 6 sq. miles in area and 100 ft. deep. If the estimated cost of this reservoir be a fair criterion, the expense of the proposed system would be about $70,000,000—all for a reduction of 1 ft. in height. To raise the levees that much would cost about $5,000,000.

The reservoirs now completed at the headwaters of the Upper Mississippi River produce an effect on the low water at St. Paul of about 1.1 or 1.2 ft. On the Lower Mississippi at flood their effect is not appreciable.

Shortening the Channel by "Cut-Offs."

Cut-offs, in rivers of destructive velocity and of movable beds, are generally not approved of by engineers, principally for the reason that their effects are not permanent and they introduce another element of instability where there are already too many. Many cut-offs have occurred within the observation of persons now living, and their effects have been carefully studied. The first consequence is to accelerate greatly the velocity in the neighborhood of the new channel, both above and below,

and to produce increased erosion of banks and lengthening of bends. This action continues for many years, until, as it is commonly expressed, the river has regained its length. It is usually believed, and the belief seems to be sustained by experience, that the beds of sedimentary rivers are self-regulating. The Mississippi is fixed at its two ends; namely, at the "paleozoic shelf" or stepping-off place above Cairo (the Grand Chain) where the old formations end and the Alluvial Valley begins, and at the Gulf-level. Between these points it must have a certain slope and no more; else its velocity will exceed the limit required for stability of banks. If it does surpass this limit it becomes destructive, and erosion ensues until, by the lengthening of bends thus produced, the slope and velocity are lessened. In 1876 a cut-off occurred at Vicksburg whereby the river was shortened about 6.5 miles. In 1892 a survey showed that in a distance of about 50 miles above the cut-off and as many below, the river had regained about 4 miles.

In the "Western Pilot," published in 1825, the river-distances are given from surveys made in 1819, 1820 and 1821. At that date the distance from the mouth of the Ohio to New Orleans was 954 miles. In 1882 it was 963. In 1884 occurred the waterproof cut-off, shortening the river about 12.5 miles. Allowing for subsequent lengthening of bends, it is likely that the distance now is very nearly the same that it was in 1825. Yet, within the interval of 72 years there have occurred at least 14 cut-offs, with a shortening of at least 160 miles or so.

There are other objections to cut-offs in rivers of the type of the Mississippi, but they need not be considered here. In very sluggish and tortuous streams they may be beneficial in the reclamation of lands, though they are usually more or less detrimental to navigation. As applied to the rapid and unstable Mississippi they are altogether out of place. They produce violent changes of regimen, tearing away valuable plantations and destroying costly lines of levee on the one hand, and condemning considerable towns to decay on the other, by leaving behind them extensive sand-bars or upon unravigable channels; and all without accomplishing any good purpose.

Artificial Outlets.

The most popular and most plausible project for the relief of the river from excessive floods is the "outlet plan." The natural remedy for a superabundance of water is to let some of it out. What is then the objection to this plan?

The term "outlet" is applied indiscriminately to two very different things—to lateral weirs, which waste portions of the water over the banks, and to great artificial channels near the lower end of the river, which are in fact, additional mouths. Considering the former, the most practical difficulty that is encountered in the location of the weirs. There is no place for an outlet on the left bank above Baton Rouge. Water escaping into the Yazoo Basin would be returned at the mouth of the Yazoo River. Even below Baton Rouge the outlet would lead into the shallow waters of Lake Maurepas and Lake Pontchartrain and soon silt them up. For this reason such an outlet was rejected from Colonel Eilet's scheme. The weirs must then be on the right bank. To this arrangement the Mississippi man, as a general rule, interposes no strong objections, but the Arkansas and Louisiana people protest violently. They say an outlet would overflow their lands just as a crevasse does. This is true. There is a great deal of misunderstanding as to the condition of the Mississippi Valley. It is commonly supposed that a large proportion of it is irreclaimable swamp, that its lakes and lagoons afford a large reservoir-space, and that its bayous could be made to carry off a great volume of overflow-water. These suppositions are far from the truth. There is very little waste land in the alluvial valley. The drainage is all away from the Mississippi, and by numerous water-courses into one main tributary, as the St. Francis or Yazoo. Therefore, nearly all the land is easily drained, and in fact is susceptible of cultivation without resort to artificial means. The lakes are very shallow and of very limited area, and are usually filled, in time of flood, with rain-water. The bayous are deep, but narrow, tortuous, and of flat slope, and are not adapted to carrying large discharges. In the progress of settlement, the banks of the small streams are the first places cleared and cultivated, from the excellent drainage and from the alluvial ridges which have been formed in such localities. A waste-weir, or series of weirs, which would reduce the water of the river enough to do any good, would cause the bayous to overflow their banks. To avoid this calamity it has been proposed to levee the outlets. It costs as much, however, to levee a small stream as a large one. If such a means has to be adopted, it would be better to spend the money on the levees of the main river.

The relief obtained from outlets is largely local, and there are good reasons for thinking that it will be only temporary. It is found, from experience with crevasses, that an outlet depresses the water-line most in its immediate vicinity, and that the effect diminishes in magnitude both above and below. This year, in the neighborhood of the Stokes crevasse, and 36 days after its occurrence, at station 675, about six miles above the break, the river stood 1.85 ft. below the high-water of 1893; at station 700, 2.2 ft.; at 723, 2.25; at 745, 2.6; at 760, 2.7; at 785, 2.7; at 820, 3.1; at 960, 3.55; in the break, at station 1,000, 4.4 below 1893. There were no crevasses in 1893, and the high-water line of that year was normal.

This phenomenon may be easily explained. Above a crevasse, the discharge is not lessened by reason of the break. The height of the water is somewhat reduced and consequently the cross-section. The diminished mean depth tends to lessen the velocity. But the velocity must be increased to carry the discharge with the diminished cross-section. Therefore there must be an increase of slope, as is shown by experience. Suppose a crevasse to lower the water-line in its immediate vicinity 1 foot. It will also lower the water-line above it, but not by so much as 1 ft. If it did, the slope would remain unaltered, and the diminished velocity, with the diminished cross-section, could not carry the discharge, which is uncharged.

The outlet will also lower the water-line below it, but not by so much as 1 ft. The slight flattening of the slope compensates for the slight increase of mean depth and cross-section as compared with those in the immediate neighborhood of the break. The Panther Forest crevasse in Arkansas, in 1882, lowered the river, at the point of occurrence, about 1 ft. The effect produced at Arkansas City, 13 miles above, was estimated at 0.3 ft. At Greenville, 27 miles below, it was 0.6 ft. At Vicksburg, 148 miles below, It was about 0.3 or 0.4.

It is generally agreed that the power of water to transport sediment is dependent on velocity. Now, the reduction of volume caused by the outlet will produce a diminution of velocity. In the Mississippi, it is believed that even a slight decrease of current will bring about a deposit of sediment, and eventually a deterioration of the river-bed. In the case of this river, observations have been conducted for too short a time for trustworthy conclusions to be drawn. In Holland, however, outlets were habitually used for a century or more, and their behavior was closely observed. When the writer was in Holland, several years ago, he made particular inquiries as to the results of the experience thus had. An eminent writer says:*

"It is an axiom of river engineers that every river must carry its own water to the mouth. . . . . The Waal is injured by the outlets from Heerewaarden to Loevestein. At high stages, as the river is loaded with silt, this latter is dropped by the sudden loss of velocity, so that recently considerable sums have been spent in restoring the depth by dredging."

Here are the opinions of some well-known engineers, expressed in conversation and by correspondence:†

"The Dutch experience with outlets is all against them. They cause shallowing of the river, and hence (especially) ice-gorges."

"The outlets were dangerous and detrimental on two grounds. First, they caused a slackening of the current, and consequently deposit and shallowing; and second, by the same slackening, the movement of ice was impeded and gorges formed. The principle is now utterly condemned."

"Formerly along all our large rivers we found such outlets, which were made to allow the water to escape sideward, especially by an ice-gorge. This system is generally out of practice at present, as it is stated to be no good at all. The river must be capable of carrying off its own water. . . . The outlets are filled up to the height of the dikes, and at present only two exist, in the southwest Maasdyk, namely, the Beerrsche Maas and the Bokhovensche Overlaat; but they will disappear as soon as the new mouth of the River Maas is ready."

This scheme of lowering the level of the flood-water by a large outlet near the mouth seems to possess a great attraction for the public. It has been advocated by only one engineer of eminence, and that a good while ago—Col. Charles Eilet—but it is revived every few years. The plan is, in brief, to open a shorter channel to the Gulf by a large canal, and thus reduce the flood-height in the lower reaches. This effect, it is claimed, would extend to the whole upper river, and, indeed, it is contended by some that it would be greater at Vicksburg than at New Orleans, and greater at Cairo than at Vicksburg.

This is one of the plans to which river-engineers are strongly opposed, for they believe it would be not only useless, but mischievous. No one doubts indeed that the flood-line at New Orleans would be lowered for the time; but it is denied that this lowering would be either far-reaching or permanent. The best results that could happen would be for the outlet to close itself again, as it very probably would. If it did not, it would either become the principal mouth of the river or it would deteriorate and eventually ruin the old mouth; in either case utterly reversing existing conditions and undoing the good work of many years of both nature and man.

The claim that the lowering of the flood-level at New Orleans would extend indefinitely up the river is opposed to all experience. Allusion has been made to the local nature of the relief from lateral outlets. We have still more emphatic evidence in the case of large terminal outlets. The great Nita crevasse, in 1890, caused a fall at College Point, 4 miles below it, of 3.5 ft.; at Carrollton, 58 miles below, of 2.15 ft.; at Plaquemine, 46 miles above, of 1.9 ft.; at Baton Rouge, 66 miles above, of 1.4 ft.; at Bayou Sara, 100 miles above, of 0.2 ft.; while at Red River Landing, 134 miles above, the effect was absolutely inperceptible.*

Should this condition not be permanent, and the influence of the outlet, after a term of years, be extended further upward, we should have the same consequences as from a cut-off; that is, the increased velocity due to the steepened slope would cause bank-erosion and lengthening of the bends, until a condition of stability was again reached. In other words, that would occur which is least to be desired; namely, a condition of chaos. What engineers, planters and merchants wish is a maintenance of the existing state, as nearly as may be; so that if a man builds a levee or a warehouse, or buys or leases a plantation, or invests money in town-lots, he may have some reasonable assurance that his property will remain there.

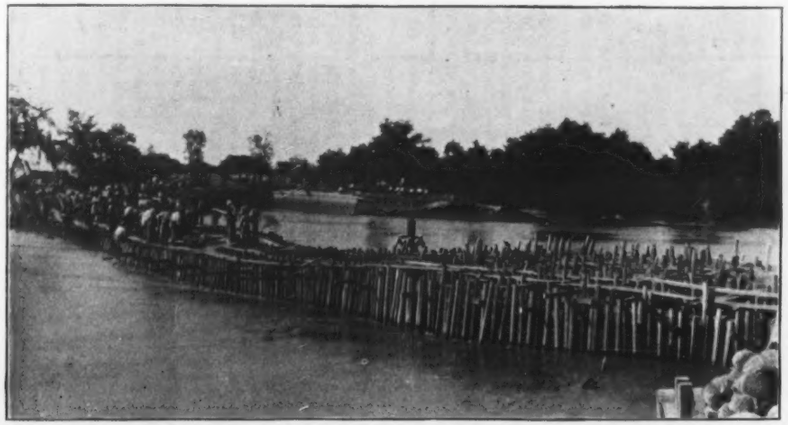
The diversion of great tributaries usually involves problems which have not presented themselves to the imaginative gentlemen who propose it. To turn the Tennessee into the Warrior or the Arkansas into the Ouachita through the intervening mountain-spurs would be a more formidable undertaking than the excavation of the Panama Canal.

Efficiency of the Levee System.

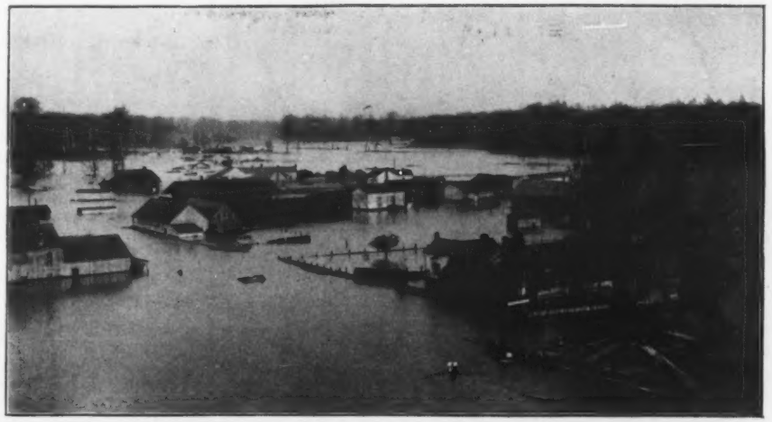
In this exceedingly hasty summary it has not been possible even to glance at many of the interesting points which present themselves. Enough has been said, however, to show that the question is not so simple as it has often been represented. The principle reason that levee-engineers usually deprecate opposition to their system is because they think it bad policy to have divided councils in time of emergency. The best study they can give to the subject—and some of them have given a great deal—leads them to think that levees are

*Transactions Am. Soc. C. E., Vol. XXVI., p. 651.
†The same, p. 651.

*See Colonel Suter's paper on "Effects of Crevasses upon Gage-Readings below Red River in 1890," in Report of Miss. River Commission for 1891, p. 3445.



CLOSING THE CONRAD CREVASSE BY A PILE DIKE.
(Copyrighted, 1897, by Robinson, Baton Rouge, La.)



PART OF ROSEDALE, MISS., DURING THE FLOOD.

THE DEERFIELD CREVASSE, FROM THE SOUTHERN END.

THE STOKES CREVASSE, FROM THE NORTHERN END.
(Copyrighted, 1897, by Coovert, Greenville, Miss.)

STRENGTHENING A LEVEE NEAR NEW ORLEANS.

A TOPPED LEVEE AND BREAKWATER NEAR NEW ORLEANS.

WATER RUNNING OVER TOP OF OLD LEVEE NEAR GREENVILLE, MISS.

TOPPED AND REVETTED LEVEE IN NEW ORLEANS.

THE MISSISSIPPI FLOODS OF 1897.

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the most efficient, cheapest and most certain means of securing the lowlands from inundation, while preserving existing conditions and improving rather than deteriorating the channel. Very considerable progress has been made toward the completion of a levee-system, and it may be said that the end is plainly in sight. The engineers, then, and others charged with the responsibility of protecting the lowlands, deprecate the dissipation of their none-too-plentiful funds in experiments which will certainly be costly and which they believe will be unsatisfactory or actively harmful, when a plain road to safety lies before them. Half of this road has been traveled. It is not short at best; but it may be made indefinitely longer if we stray into every by-path that presents itself.

The objections which have usually been urged against levees are; first, that they are too precarious—that they cannot be made strong enough to be secure against breaking; second, that they cost too much; and third, that they raise the bed of the river by confining within the channel the silt which otherwise would be carried over the banks and be deposited on the adjacent bottom-lands.

The first objection will not be entertained by any engineer when he hears that the highest banks do not exceed 40 ft., and that this height is only for a few hundred feet at most. It is, then, practicable to make the few high levees of any dimensions that may be necessary for safety—with slopes of 1 on 10 if less will not do—without inordinate expense. No such proportions have ever been found necessary. About 1 on 5 is the flattest slope that has ever been used. It is not the great levees that break.

Even when ultimate grade is attained, say 3 ft. above the "potential high water" of 1897, the average height of the levees will not exceed 18 ft., of which 3 will be a margin against storms or accidental deficiencies, settling, etc., leaving a waterhead of 15 ft. Extreme high water will last only a few days; within a foot of extreme height, may last 3 or 4 weeks. For such embankments, in ordinary soils, slopes of 1 on 3, with banquettes, will be sufficient. Banquettes should be 8 ft. below grade, or 5 ft. below potential high water, width of crown from 20 ft. up, according to size of levee. The foundation should be carefully prepared, and the bank put up in layers, and preferably rolled. For light soils or very high levees, special dimensions must be adopted.

Of all the crevasses in the levees of the Yazoo Basin this year, not one was in a new levee. All the embankments which broke were built as much as 30 years ago, and most of them before the War. It was not age, however, which made these levees unfit to be trusted, but unsoundness. It was formerly not the custom to grub or blast out stumps or roots. Trees were merely required to be cut down level with the ground, and even this requirement was not strictly enforced. There was no careful supervision or inspection. The older levees were built by the planters themselves, engineers being engaged by the day, it is said, to stake off the work and (perhaps) to receive it. Even at a later date, no resident inspectors were employed. The engineering force was very small, and the engineer never saw his levee except when he took up estimates, and not always then. Even without intention of fraud, in emergencies, logs, rails, etc., were thrown into the bank to expedite and cheapen the work. In fact, it was not till 1890 that real strictness in levee-building became the rule.

The stumps, roots and logs put into the levees 30 or 40 years ago have now rotted away, sometimes leaving their traces in the shape of "sinks" in or near the levees, sometimes as so-called "crayfish-holes," sometimes presenting no external symptoms of unsoundness until a hole, a "boil" or an actual break reveals the weakness. In Arkansas, where the levee system was nearly all rebuilt in one or two seasons, the old levees, which were insignificant in size, were thrown away altogether or were transplanted to a new location a hundred feet or so away, properly prepared. In Mississippi, however, the old levees had, by continual patching, grown to considerable proportions. They constituted three-fourths of the whole line. They could not, therefore, be thrown away. They were merely enlarged, but, as the result shows, insufficiently. The engineers have done what they could with the money at their disposal, but it was too little.

Sound earth is a good enough material for levees, without iron, brick, concrete, wood, paper or glass, but the bank must be carefully built, of sufficient dimensions, and, especially in case of a light or treacherous underground, must have its base extended by a banquette.

As to cost, it may be briefly said that levees are the least expensive means of reclaiming overflowed lands that have ever been proposed.

Raising of River Beds by Deposits of Silt.

The idea that confining the waters of a river tends to cause a deposit of silt in the bed thereof is one that seems to have taken a very strong grip on the popular mind. Yet of all the objections which have been urged against levees this is the most groundless. It is absolutely opposed to sound reason, and it has no evidence whatever to support it. It has been disproved a hundred times, and yet it is asserted to-day with as much confidence as ever. The example which is most frequently cited in favor of such a doctrine is that of the Po. In the earlier part of this century, a distinguished French engineer, M. de Prony, after a hasty visit to Italy, reported that "the surface of the river was above the roofs of the houses at Ferrara." This statement has gained very general currency, and has been sometimes interpreted to mean that the bottom of the river was above the roofs. It was completely refuted in 1852 by Lombardini, then Director-General of Public Works. This eminent engineer proved, by reference to the foundations of flood-gates, "that the low-water surface of the river had not changed sensibly in more than two centuries; and showed, by careful leveling, that the extreme high-water mark of 1839 was 3 ft. below the top of the old embankment at Ferrara, and 5 ft. above the ancient natural bank.* There had been a rise of 3.3 ft. in the high-water mark in the last century and a half, due to the confinement of the waters from the completion of the levee system; just as there has been a rise of 5 ft. in the high-water mark of the Mississippi at Greenville in the last 15 years, from the same cause. The bed of the Po is nowhere above the level of the adjacent country, even in the deepest swamps.

The misstatement seems to have taken much firmer hold than the refutation; for, while the latter is or ought to be well known to engineers, and has repeatedly been given currency,† it appears never to have reached the newspaper writer on high-water.

The Hwang-Ho, or Yellow River, of China, is also often cited as a proof that embanking rivers raises their beds. There is no analogy between the two cases. The Mississippi, in its alluvial part, runs between parallel ranges of hills, about 35 miles apart, by which its lateral excursions are limited. Of its three great components, only one, and that the least, carries any large load of silt. The others, comprising three-fourths of the whole, are clear-water streams. There is a superabundance of velocity, and power enough, not only to carry the burden of sediment to the sea, but also to take up more. The Yellow River, in its upper portions, is more like the upper Arkansas or Platte. It runs through sandy and arid plains, decreasing rather than augmenting its volume of water, till it reaches the mountainous province of Shan-si, composed of carboniferous hills capped with loess, which deflects the river to the south. From this point on it receives several large and rapid affluents, heavily charged with loess. In fact, the loess formation is the prevailing feature of the geology of the country throughout the remainder of the course of the river through the uplands and even along the southern border of the Great Plain. It is as if the Ozark Mountains were composed of loess, in hills 2,000 ft. high, intersected with large and powerful streams, and as if the Arkansas, after receiving the contributions of yellow mud brought by these tributaries, should be turned into an almost limitless flat plain, to find or make its bed. If the river was fully loaded coming through the mountains, it will not be able to carry its burden after its descent to the plains, but must lay down a part of it, levees or no levees. It is not contended that confining a river will prevent altogether the silting-up of its bed, if such be the tendency of the river, to a marked degree, in its natural state. It is only affirmed that it has a favorable influence that way; and that if a river raises its bed when leveed it would raise it still more without levees.*

The idea that confining a river should cause it to deposit silt is so contrary to reason that it is a wonder it ever obtained credence at all. Transporting power is generally believed to be proportional to the square of the velocity. The confinement of the stream unquestionably gives increased current. Undoubtedly, in retaining the water within the channel we also retain the silt, but at the same time we retain the vehicle by which to carry it, and give that vehicle greater capacity. Observation shows that since the Mississippi has been confined between levees its tendency has been rather to erode than to deposit, as has been demonstrated by caving banks. The best test of the condition of the bed is to be found in low-water observations. At such stages, the water-surface conforms more closely than at any other to the bottom of the river. Now in 1887, 1888, 1889, 1891, 1892, 1893, 1894 and 1895, since the levee-system was made continuous below the mouth of the Arkansas, the river below Cairo was exceedingly low, and in the two years last named it went far below all previous records. That this was not due to paucity of water is shown by gaging. For equal stages, each of these years exhibited an increase of low-water discharge over its predecessors.

The evidence, up to 1890, is well shown by General Comstock, then President of the Mississippi River Commission, in the paper already alluded to. His conclusion is that in the cases of the Po and the Rhine the rise, if any, is insignificant, and that in the case of the Mississippi there is no evidence of any rise at all. It may be added that not one of the engineers who have written systematically upon the Mississippi, from Charles Ellet and Humphreys and Abbot to the Mississippi River Commission, believes that levees have any tendency to deteriorate the bed of the river. Nearly all of these writers have been non-residents of the Mississippi Valley, and absolutely without personal interest or bias.

TWELVE PLANS FOR A NEW WATER SUPPLY FOR Philadelphia have been submitted to the city council within the past two years or so, nine of which are still before that body. One plan proposes a supply from the southern part of New Jersey, by pumping. Another is for artesian wells. A third and fourth are for gravity supplies from the Lehigh and Susquehanna Rivers, respectively, and a fifth is for a supply from the Schuylkill River, above Norristown, clarified by sedimentation and conveyed by gravity to the lower and by pumping to the higher levels of the city. The remaining seven schemes all invoke water purification, two mentioning no source; four proposing the Schuylkill and its tributaries and one the Delaware, above Trenton. The latest proposition is virtually only an offer to transfer the rights of the Schuylkill Navigation Co. to the city, in exchange for which the city would bear that portion of the expense of the Reading subway that is now to be borne by the Philadelphia & Reading Railroad Co., which controls the water rights named. The subway is now under construction and the company's share of the work is estimated at about $3,600,000. After acquiring these rights the city would still have to enlarge its pumping plants and reservoir capacity and build new filters. Most of the other propositions, involving filtration, call for annual payments by the city for filtered water, the filter plants, in several cases, to become the property of the city at the end of 50 years. One of the purification projects is a so-called electrical plan; the others involve sand filtration, either the ordinary filter beds, or some patented process not to be classed as the common form of mechanical filtration. The details of all these schemes are given in the Philadelphia "Public Ledger," for June 21. Three of them have no semblance of life and most of the others show little signs of it. It seems more than likely that all of them may fail through.

*See Humphreys and Abbot, pp. 441 and following.

†See General Comstock's "Memorandum on the Question Whether Building Levees Along a River Causes the Bed to Rise," in the Report of the Mississippi River Commission for 1890, pp. 3003 and following. See also the testimony of General Comstock and Captain Leach before the Commerce Committee of the Senate in 1890.

*Information about the Yellow River was derived mostly from Mr. J. G. W. Fijnje's "Memorandum on the Improvement of the Hwang-Ho," "The Hague," 1891, and from Richthofen's Atlas of China; also from General Wilson's book on China, and from General Comstock's "Memorandum," etc., previously quoted. (Report of Miss. River Commission for 1890, pp. 3008 et seq.)

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It is generally accepted by engineers that a riveted joint must have a less strength than the solid plate which it joins. We record in this issue, however, a bursting test of a steam boiler in which the failure occurred in the solid plate, and at a pressure which must have strained the metal of the shell some 72,000 lbs. per sq. in., or 20% higher than its stamped tensile strength. Evidently, if the rivets of a joint held only by their resistance to shear, and the plate were of uniform strength in every part, failure would always take place at the joint, as indeed it almost always does. No matter what form of joint we select, the row of rivets at the edge means a row of perforations which reduces by so much the cross-section of the plate. It is true that the strength of the plate at this section is not reduced in proportion to the reduction in cross-section; but the reduction is nevertheless great enough to make this, under normal conditions, the weakest point in the plate.

How, then, is the failure which occurred in this case to be explained? Various reasons may be offered. Some flaw or weak spot may have existed; in fact, it was at the feed pipe opening that the break started. Again, with a newly-riveted joint the friction of the rivet heads, gripping the plate like the jaws of a testing machine, probably helps somewhat in taking the tensile stress and relieving the weakened section through the line of rivet holes.

But this frictional hold of the rivets, while it shows good workmanship, cannot be safely relied upon as a permanent element of strength. The safe course for the designer is to calculate the strength of any riveted joint as less than that of the solid plate by at least the percentage which the section of the plate is reduced by the last row of rivet holes.

The Merchants' Association of San Francisco seems to be doing excellent service in the interest of better public works and municipal reform in general. Some time ago we noted the fact that it raised $30,000 and undertook the cleaning of the streets for eight months, after which the system and specifications of the association were adopted by the city. Quite recently $14,000 was raised for six months' street lighting by means of 228 arc lights of 2,000 c. p. each. It is hoped that the object lesson thus furnished will lead to marked improvements in street lighting. The association is now actively working for better pavements, better sewerage, a new charter, and various other things deemed important to the city's welfare. The association now numbers 873 members, individuals and firms, having increased to this figure from the original 47 members of three years ago. Any business firm of good standing may be a member by paying dues of $1 per month. Each firm has but one vote, but may be represented at any meeting by any or all of its members, or by such employees as it may designate for that purpose. Members are entitled to consultation, without charge, with the attorney of the association upon civic or business matters, and with its civil engineer on matters pertaining to engineering and sanitation. Mr. J. Richard Freud is Secretary and Attorney, and Mr. Ernest McCullough is its Consulting Engineer. The above information is taken from the "Merchants' Association Review," for June, 1897. The "Review" is published monthly by the association and sent without charge to the members and to a large number of others. It accepts no advertisements and publishes nothing of a political, sectarian or personal character.

The plan and methods of this association have much to commend them and the commendations seem justified by the results obtained. The greatest bane of municipal government is indifference on the part of its supporters. Often those most dependent for business success upon the proper conduct of municipal affairs take the least active interest in them. The influence that may be wielded by an association of nearly a thousand individuals and firms, almost wholly the latter at San Francisco, on municipal officials and the general public can hardly be over-estimated. Public opinion is a great power, but intelligent public opinion expressed by a well-organized body of influential citizens, directed, in turn, by expert advisers, is more effective still. It is more likely to strike while the iron is hot, and in fact it often heats the iron, and strikes with well-aimed blows. The hammer of public opinion needs to strike with well-aimed blows, because otherwise, if it hits at all, it will only warp and twist the iron; and it needs to strike hard blows, or the principal result will be a momentary clatter.

There is plenty for the San Francisco Association to do before the public works of that city are all put on a sound engineering basis; and while San Francisco has great need of its efforts, especially in the matter of sewerage, there are numerous other cities which need the efforts of similar organizations.

In our issue of May 27 we published a letter from Mr. F. C. Moore, President of the Continental Insurance Co. and a member of the Board of Examiners of the Building Department of New York city, in which he stated his position with regard to the various forms of fireproof floor now in the market. Several statements made by Mr. Moore in that letter appear to us to call for a public answer, in the interests of sound engineering and safe building construction. In our present issue we publish an answer to Mr. Moore's letter, written by Mr. Gus. C. Henning, M. Am. Soc. M. E. Mr. Henning was employed for several months by the Building Department as an expert to conduct the tests of various forms of fireproof floors which were made under its auspices and have been reported in our columns, and his answer to Mr. Moore is therefore of especial interest.

To one point which was raised in Mr. Moore's letter and on which Mr. Henning does not touch, we deem it well to call especial attention here.

Mr. Moore says in substance that he objects to any floor construction composed of a combination of iron or steel members and concrete because "It has not yet been demonstrated (for only experience can demonstrate the fact) that the iron will not rust out in course of time." It appears to us that in making this statement Mr. Moore is ignoring a well-established fact of engineering and is taking a position which cannot be maintained. We believe it is a fact about as well established as anything in engineering science that iron or steel which is encased in mortar of either lime or cement will be permanently preserved from corrosion. This is of course what would naturally be expected. Corrosion can only take place when a supply of oxygen is furnished to the surface of the metal, and when a piece of steel is embedded in concrete it is hermetically sealed in stone. It may be said that the stone is more or less porous, but even if this be true the porosity is not such as to permit circulation of the air to and from the surface of the metal.

But engineering knowledge on this subject is not confined to theory. Engineers know from thousands of recorded instances that iron or steel embedded in mortar is preserved for many years without loss of section. And, knowing this, it appears to us like infinitesimal hairsplitting to question the durability of a combined concrete and metal floor on the ground that the metal embedded in the solid concrete may rust out in course of time. If iron or steel embedded in concrete is preserved indefinitely in one situation it will be in another, provided, of course, that there are no circumstances in the latter which change the liability to corrosion.

But what seems to us the weakest point of all in Mr. Moore's position is his neglect of the fact that it is not the absolute safety of concrete floors that is under consideration, but the relative safety of floors of concrete and floors of tile. Mr. Moore says in substance: the law specifies tile floors, hence the Board of Examiners assumes that tile floors are safe and accepts no responsibility concerning them. We must dissent emphatically from logic of this sort. Except by a strained construction, the law does not specify tile floors. What it specifies is brick or stone arches, and it allows as an alternative terra cotta or some equally good fireproof material. And it is for the Building Department to decide whether the concrete and other constructions are as good as terra cotta. Manifestly this opens up the subject of the merits and demerits of terra cotta or tile, and we would respectfully inquire of Mr. Moore how much he or any one else knows as to the absolute strength and fire-resisting qualities of tile floors? If he is candid he must acknowledge that very little, if any, more is known about the strength and safety of such floors than is known of the strength and safety of concrete floors. The tile floors have been used a few years longer and in a greater number of buildings, but that argues nothing as to their strength and fireproofness. What we know about either tile or concrete floors as respects their strength and safety we know from the tests of the two that have been made and from the experience in a few fires that have occurred in fireproof buildings. Taking European experience with American, we are inclined to think there is approximately as much information respecting the strength and safety of concrete and steel constructions as there is of the strength and safety of tile. How then are Mr. Moore and the Board of Examiners justified in setting up tile as a better material than concrete for fireproof floors? Will they give to the public the specific facts, which we assume must be in their possession, in connection with the behavior of concrete floors in tests or in fires which cause them to turn them down in favor of tile?

In any event we trust that the Board of Examiners may cease to hide behind the pretext that the law has established tile as the standard construction, in view of the fact that the law as it stands was in large part drafted by some of the most prominent members of this Board.

The Westinghouse high-speed brake, which is illustrated in this issue, will be a boon to signal engineers on roads running very high-speed trains. It is admittedly sound doctrine that the distant signal should be so far from the home signal that the highest-speed trains passing the distant at caution can be stopped before reaching the home signal. But the farther off the distant signal from the home, the greater are the chances of difficulties in its working, especially in bad weather, and the heavier is the expense for its installation and maintenance. At present the high-speed brake is used only on a few very fast express trains, but it is so simple an apparatus and the change of the regular quick-action brake to this form is so readily made that we see no reason why this apparatus should not be adopted on all fast passenger trains. The increased stopping power which

is secured by this apparatus is so considerable that it seems to us likely that some railways which now use 2,000 ft. as the standard distance between the home and the distant signal could reduce this to 1,800 ft. or even less without incurring danger.

We are sure our readers will welcome with interest the admirable paper by Mr. Starling on the Mississippi Floods of 1897, with its graphic illustrations, which we present in this issue, and especially what he has to say concerning the various schemes which are periodically brought forward for the control of the great river. Most of the newspaper discussion on the Mississippi problem, which Mr. Starling so well characterizes, is carried on by men who are in entire ignorance of the facts in connection with that problem. For instance, the man who declares that only a system of scientific forestry can prevent the Mississippi floods, does not know that the present year's flood came chiefly from the heavily forested portions of the Ohio drainage basin; nor is he aware that floods in the early part of the century when practically no timber had been cut on this basin, had probably as great a volume of water as the flood of 1897.

With the extended array of facts concerning the Mississippi and its control which have now been published in these columns, our readers are in a position intelligently to understand the problem which is presented to the dwellers in the lower Mississippi valley and their engineers.

We take pleasure in announcing that Mr. Starling's three contributions which have been printed in this journal, will shortly be published separately, and will constitute, we have no hesitation in saying, the most interesting description ever presented of the Mississippi River and its flood protection works.

THE PRESENT STATUS OF MOTOR-DRIVEN VEHICLES FOR COMMON ROADS.

The most elaborately planned trial of motor carriages that has ever been made was that which was announced two years ago by our contemporary, "The Engineer," of London. The prizes offered amounted to $5,000 in round numbers. The fact that the offer was made by a journal devoted to engineering and that the prizes were to be awarded by a distinguished commission of engineers made the competition at least equal in importance to any that has ever been held for the promotion of the motor-carriage industry. The date of the competition, which was announced in July, 1895, was originally set for October, 1896, but it was postponed later to June 1, 1897. The results of this competition were described in detail in "The Engineer" of June 4, and may be briefly summed up as follows: Seventy-two carriages were entered for the competition, but as the date of the trial approached one after another was withdrawn, the excuse generally given being that the vehicle could not be completed in time. Finally, on the date set for the trial, five competitors only were on the ground ready to take part. The carriages offered included one each propelled by steam, electricity and gasoline, and three driven by oil engines using non-volatile petroleum oils.

The judges of the competition, Sir Frederick Bramwell, Mr. Aspinall and Dr. Hopkinson, examined these various vehicles and saw them driven about the grounds of the Crystal Palace and put through various tests and manoeuvres. They then decided that under the terms of the competition none of the vehicles exhibited were entitled to prizes, and hence the contemplated trial run to Birmingham and return need not take place.

In commenting on the results of its competition, "The Engineer" says:

> One result of our essay has been satisfactory. It has cleared the air. It has placed the world in possession of facts concerning the motor car industry in this country. There is at present no such industry. There is no such thing as a thoroughly satisfactory self-propelled vehicle. If a motor car of the kind existed, it would have been submitted for competition. We have received dozens of applications to postpone the trial. The period of delay asked for varied between one month and one year. It will be remembered that several months have elapsed since the world was assured that the construction of motor cars was a flourishing industry. Already we have put off the date of trial from October, 1896, to June, 1897. We have to deal with things as we find them. We have every reason to believe that the best that England can do at present was shown at the Crystal Palace on Monday; and, in the opinion of three most competent engineers, the carriages shown were so imperfect, so unsuitable to the fulfilment of the purposes which a motor car ought to serve, that they would not submit them to further trial. Administering the funds placed at their disposal to award as prizes, the judges have held that none of the vehicles so nearly satisfied the conditions with which a self-propelled motor car must comply, that it was entitled to the final and crucial test of a long run. As we interpret this decision, it means that even if any of the cars had to run to Birmingham and back within the prescribed period, that fact alone would not have compensated for its defects.
>
> The motor car has yet to be made. It may be that it has not yet been invented. This we say with a full appreciation of what has been done in France. It must not be forgotten that what will satisfy our French neighbors will not at all satisfy public opinion in this country, which is much more exacting. And then after all comes the question—are motor cars wanted? Will there ever be so full a demand for them that money can be legitimately made out of their manufacture? There are not lacking those who assure us that the motor car has been slain by the tramcar and the bicycle. Time alone can settle the question. The world may rest assured that if a motor car is really needed, it will in time be produced.

The above must make interesting reading for the British public, which has purchased so heavily of the shares of the "horseless carriage" companies that have been promoted so industriously in England during the past two or three years.

The fact is that the chief energy of those who have been engaged in the motor-carriage industry in England has been rather to get "show" results which would attract investors than to develop really practical and commercial machines suitable for placing on the market. The competition which our contemporary established has brought this fact to public notice, and while it comes too late to help the thousands of deluded investors it is of no small value as evidence respecting the status of mechanical propulsion of vehicles on common roads at the present time in England.

As if to corroborate the conclusions which the dispassionate observer naturally reaches from the result of "The Engineer's" competition comes the news of a similar outcome from still another motor-carriage competition. This was the exhibition of the Royal Agricultural Society at Crewe, just following that of "The Engineer," which it was expected would attract a great number of exhibitors; yet only three entries were made for the society's prizes, and but one of the vehicles appeared on the date of the trial.

It is interesting in this connection to review recent history a little. If the reader will turn to our issue of Aug. 23, 1894 (p. 146), he will find an account of the famous "Petit Journal" motor-carriage competition in France. In this competition there were no less than 102 carriages entered, of which 26 actually took part in the road race. Since that time a number of motor-car competitions have been held in France, all of which, so far as we recall, have been participated in by large numbers of vehicles.

In this country the Chicago "Times-Herald's" motor-carriage competition of Nov. 28 1895, was participated in by six vehicles.

These competitions and the agitation of the question of mechanical propulsion on common roads which they induced, were responsible for a vast amount of public interest in the subject two years or so ago, and, as many of our readers may recall, the newspapers were, as usual, ready with their prophecies of the total supplanting of the horse by the motor vehicle. It was for a time a public craze, and the promoters in the London stock market took advantage of this craze to line their pockets.

In this country at least the craze period seems to be over; people are ready to consider the motor carriage on its merits—if it has any—and the present seems an appropriate time to sum up the progress that has been made and inquire what the present situation and outlook for the motor carriage may be.

The most important question respecting the motor vehicle is of course, as it always has been, the question of the motive power. The bicycle builders and the carriage builders can produce vehicles for any desired class of service which combine strength, lightness and ease of running and steering to a marvellous degree, and which would doubtless be practically and commercially successful for many classes of service if a satisfactory motive power were supplied. But the question, which is the best motive power for this purpose of the several which have been used, is still an open one, and it is not yet even certain that any one of these forms of motive power is good enough to make a motor vehicle using it commercially successful.

As many of our readers are aware, the Pope Mfg. Co., at the time when the popular interest in motor vehicles was at its height, a couple of years ago, announced that it was erecting and fitting up a shop especially for the manufacture of motor carriages. Very recently it has announced that its motor carriage is ready for the market, and it is of great interest to note that it has adopted, to drive this vehicle, an electric motor driven by storage batteries. Here is a wealthy and enterprising corporation with the highest grade of executive talent and engineering ability in its service. It is safe to assume that the relative merits of the various available forms of motive power were carefully investigated and tested by the Pope Company's experts before the final decision was reached. The motor carriage which has been developed as a result of their decision has 800 lbs. of storage battery cells, requires recharging every 30 miles and costs the tidy sum of $3,000. Such a vehicle is an admirable toy for a wealthy gentleman of leisure with a taste for things mechanical, but it is certainly plain that it is far from being a commercial success as a competitor of the horse for either business or pleasure purposes.

The steam engine has been tried longer than any other motor for propelling vehicles over common roads. A considerable degree of success was attained with it over seventy years ago, and at the present time steam carriages of remarkable perfection and ingenuity have been constructed by inventors in France, England and America. The inherent objections to the steam-motor carriage are its necessary complication, the nuisance of the exhaust steam and the weight of the water that must be carried. All these together have thus far been sufficient to prevent any steam-driven vehicle for common roads attaining commercial success.

If neither steam nor electricity is at present a success, the only other form of motor worth considering for this purpose is the internal combustion engine. We believe it is not too much to say that the revival of interest in the mechanical propulsion of vehicles on common roads is due more than anything else to the advancement which has been made in recent years in the construction of light, compact, internal combustion engines using some form of petroleum as a motive power. It is also fair to say that the nearest approach towards commercially successful vehicles for either pleasure or business which has been made has been with vehicles propelled by such motors.

There are two classes of these motors. The first and by far the most numerous class uses gasoline, benzine or some of the volatile distillates of petroleum; the second uses some non-volatile petroleum oil.

It is objected to the first that it is dangerous, and to the second that, owing to the difficulty of securing perfect combustion, there is much nuisance from bad odors and the machine is apt to become clogged with soot, tar, etc.

The most successful motor vehicles yet built, to the best of our knowledge, have been propelled by these volatile fluids as fuel, and in America and France the dangers attending their use are not usually considered serious. In England, however, where the sale and use of gasoline and similar fluids is regulated by law, there is a general feeling against this class of motor vehicles. "The Engineer" in its competition, at first planned to exclude vehicles of this class entirely, and later arranged for their entry in a class by themselves and for a prize smaller in amount than the other prizes. It is quite probable that in this is to be found in large measure the explanation of the small number which participated in "The Engineer's" competition.

Very likely it was this matter of danger which caused the Pope Mfg. Co. to adopt the storage battery, with all its well-known imperfections, rather than the gasoline motor to propel its motor carriage. It is of course true that gasoline is, like gunpowder, an inherently dangerous substance, and a great concern like the Pope Company naturally dreads the inevitable accident which somebody's carelessness is sure to bring

about sooner or later, and the blame which would inevitably be laid at the door of the maker of the carriage no matter how guiltless he might be.

And yet, notwithstanding "The Engineer" and the Pope Mfg. Co., we are by no means convinced that the gasoline motor is not the best system now available for mechanical propulsion on common roads. Accidents will occur with it, of course, occasionally; but we see no reason to believe that they will be so frequent as to discourage the public from its use. There are now in this country some thousands, we presume, of gasoline launches, and a still greater number of stationary engines using gasoline. Gasoline stoves are used in many households, and either gasoline or some similar volatile oils are in use to a greater or less degree in tens of thousands of industrial establishments. Accidents occur of course, but they are not so frequent that the public gives up the use of gasoline. We do not see why this experience is not applicable to the case of motor carriages.

If any one can build a motor carriage in every way as good as that propelled by gasoline and use kerosene or some other heavy oil for fuel, well and good; but if this greater safety is attained at the expense of smoke, bad odors or clogging of the machine by tar and soot, we venture to predict that the public which buys motor carriages will choose the gasoline engine and run its risk of accidents.

Again, if the Pope Company or any other builder of motor vehicles can reduce the weight of the storage battery until it is no longer a serious burden, and can at the same time increase the durability of the cells and reduce the total cost of maintenance of the machine until it will stand on a par with the gasoline carriage, then the storage-battery carriage will undoubtedly have the preference.

In the present state of the art, however, the gasoline motor carriage seems to us to be nearest to real commercial success, at least in this country and in France. We say nearest to it, for it seems to us that to a large extent the motor-carriage industry is still in the experimental stage, and is not likely to pass beyond it for some time to come.

LETTERS TO THE EDITOR.

A Water-Proof Lining for Brick Sewers Wanted.

Sir: I would like to provoke a discussion through the columns of your paper concerning a remedy for defective construction of brick sewers for a separate system, so as to shut off, as far as practicable, the ground flow and infiltration of water by a coating of Portland cement plaster or Sylvester's solution applied in the interior of the sewer, with cost per square foot of surface treated, if any of your readers have figures in this line.

No laterals for the system have been built.

There is 8,140 ft. 48-in. circular brick sewer, submerged by back water; 2,500 ft. 48-in. circular brick sewer, partly submerged, 48 to 18 ins. back water; 1,070 ft. 3 × 4-ft. egg brick sewer, partly submerged, 18 to 1 in. back water; 6,800 ft. 2 × 3 ft. egg brick sewer, not submerged, which is from 15 to 23 ft. below surface of streets.

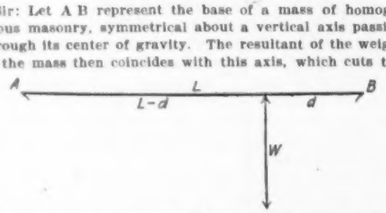
The approximate daily flow of ground water is 1,800,000 gallons. No house connections have been made.

W. X.

(We should be pleased to hear from any of our readers who can give information respecting processes for waterproofing masonry.—Ed.)

A New General Formula for Determining Unit Stresses in Masonry Structures.

Sir: Let A B represent the base of a mass of homogeneous masonry, symmetrical about a vertical axis passing through its center of gravity. The resultant of the weight of the mass then coincides with this axis, which cuts the



base A B in the middle, and the unit stress upon all parts of the base is equal to the total weight divided by the total area of base.

If, however, the mass is not symmetrical about such axis, or if it is subjected to an exterior force, such as that occasioned by water pressure, then the point where the resultant cuts the base will be displaced from the center, and will take up a position such as is shown in the figure, where W represents the position of the resultant of the total weight, or its vertical component; L represents total length of base; d and L − d represent respectively the shorter and longer segment into which the point of application of W divides the base.

The unit stress can no longer be found in the simple manner above mentioned. It is evident that the region comprising the shorter segment, d, receives a more concentrated pressure than when the resultant cuts the center of the base. In the designing of high masonry dams, it is of the utmost importance to determine accurately, or at least safely, the intensity of the maximum unit stress coming upon any part of this shorter segment.

French authors have established two formulas for this purpose, as follows:

$$P = \frac{2\,W}{3\,d} \qquad (1)$$

$$P = \frac{4}{L^2}\,(L - 1.5\,d)\,W \qquad (2)$$

In which P = unit stress at the point B. In English measures this will be expressed in pounds per square foot, W, L, and d being expressed in pounds and feet. Of these two formulas, (1) is to be used when d equals or is less than $\frac{L}{3}$, and (2) when it equals or is greater than the same.

The explanation of these two formulas, translated from the French of Mons. A. Debauve, with additional notes, is given in the second of two articles published in Vol. 30 (1884) of Van Nostrand's Engineering Magazine. A simpler treatment is given in Mr. Edward Wegmann's treatise on masonry dams. As is well known, the data of these investigations are not wholly satisfactory, and they are given rather as apologies for, than demonstrations of the formulas which spring from them. When $d = \frac{L}{3}$, (1) and (2) give identical results, and it certainly seems odd, at first sight, that two formulas so different in character, and both depending upon the value of the same variable, should have such a clearly defined point of demarcation between the values of this variable to which they are respectively applicable.

It has occurred to the writer that a single general formula, based upon a somewhat random assumption, may perhaps prove to be as near the truth as the two already given. The assumption is, that the proportion of the total weight W, borne uniformly by the two segments, d and L − d, is inversely as their lengths. Thus, the unit stress, P, throughout the shorter segment d, the only one we need consider, becomes:

$$P = \frac{L - d}{L\,d}\,W \qquad (3)$$

Comparing this formula with the two others by means of their results, we will note that it agrees with (2) when $d = \frac{L}{2}$, both giving, in this case, $P = \frac{W}{L}$. Also, they all three agree when $d = \frac{L}{3}$, in which case they all give $P = \frac{2\,W}{L}$. In intermediate values of d, (3) gives values for P slightly smaller than (2), the greatest difference being when d = about 0.42 L, when it falls below (2) by about 7%. On either side of this value of d, the two agree more closely, so that we may say that for resultants passing within the "middle third" they practically agree.

On the contrary, for values of d less than $\frac{L}{3}$, formula (3) gives values for P steadily and increasingly greater than (1). Its merit or demerit therefore hinges upon the results which it gives for these small values of d, and it is around this question that the writer hopes that the present communication may stimulate investigation and discussion. He would in such connection advance the following considerations: In the designing of high masonry dams of the gravity type, the resultant pressure should always be kept within the middle third. Outside of this, calculation becomes more uncertain, while danger increases. It would seem therefore that a formula, agreeing with an accepted one within the usually occurring cases of good design, and levying an additional tax upon departures from the same, merits consideration from the profession.

The limit of application of (1) and (3) would be when d = o. Then the mass would be on the point of overturning. We cannot of course use either in this extreme case, because both would give P = infinity, but we can make the comparison by taking d relatively very small. As a numerical example, let L = 100 ft., and d = 1 ft. Then, by (1):

$$P = \tfrac{2}{3}\,W$$

and by (3), practically:

$$P = W.$$

Now, it appears to the writer that in this case, when the mass may be considered as just about to turn over around the toe B, the whole weight, as per (3) and not two-thirds of the weight merely, as per (1), is resting, or tending to rest upon the small surface, d = 1 ft.

The writer would, therefore, invite criticism upon the formula (3), either as replacing both of the old formulas, or at least that one which applies to values of d less than $\frac{L}{3}$.

E. Sherman Gould.

Yonkers, N. Y., June 4, 1897.

The Effect of Fire on Concrete and on Tile.

Sir: Your articles on the recent Pittsburg fire, in your issue of May 20, and the letters of Messrs. Merrill Watson and F. C. Moore, in the following issue, induce me to send you a number of facts and comparisons concerning concrete and tile floors, and the actions of the Board of Examiners of the Department of Buildings of New York city, which may be of interest to your readers.

It is to be regretted that you said so little about the showing made by the concrete floors in the Methodist Publishing Co.'s building as compared with that made by the tile floors of the Horne building, especially in view of the reports on fire tests of floors which you have published from time to time since your issue of Sept. 3, 1896.

The sum and substance of results of all of these official tests, made by the order and on behalf of the New York Department of Buildings, is this:

Concrete floors resist all temperatures obtainable in ordinary conflagrations, and are not materially weakened by such fires: tile floors, of whatever construction or make, fail and are destroyed by temperatures slightly above those at which the clay of which the tile is made was baked or burned (or 2,000° F. and above). That this was the case was demonstrated by the following tests:

Concrete.	Tile.
Roebling.	Fawcett Ventilated.
Rapp.	Raritan Side Construction.
McCabe.	Central Fireproofing Co., end construction.
Thomson.	Guastavino.
Manhattan Concrete Co.	
Central Expanded Metal Co.	

These concrete floors all withstood the test most admirably, while all of the tile floors mentioned failed. Had it not been for the concrete which was above the tile in the Fawcett and the Central Fireproofing Co.'s end construction floors, they would have collapsed as did the Raritan side construction in the test of Oct. 27. I do not here mention the Metropolitan Fireproofing Co.'s test, nor the 10-in. tile test, made on May 20, 1897, because they were not made fairly, as the temperatures were kept practically below 1,900° F., while the others were made at 2,000° F. and above.

I also herewith desire to publicly enter my protest against the test-structure built by the Central Fireproofing Co., and tested Sept. 17, 1896 (see Eng. News, Oct. 1, 1896), because this floor had been built for test purposes only, selecting the very best tile and cement (Dyckerhoff), using a deeper tile than is habitually used in 4-ft. arches, or a 3-section 10-in.deep tile (an 8-in. section is the usual depth). The tile arches were built by a bricklayer who took at least thrice the time that is ever taken in ordinary work, driving slate shims wherever possible, partly filling many spaces in the tile with cement, and ramming the joints of skew-backs solidly with cement. Moreover, these tile floors in buildings are habitually laid naked between beams, while in the test structure, 4 ins. of concrete (made of Dyckerhoff cement) had been laid above the tile, which alone was sufficient to carry all the load superimposed. It will also be seen (see Eng. News, May 27, 1897) that the tile test was on 4-ft. arches built of 3-section 10-in. tile, with 2-in. concrete and concrete filling between sleepers, on top, instead of using loose filling such as dry lime, ashes, cinders, etc., which are habitually used in the best structures in the city.

On the other hand, I can emphatically state that all of the concrete floor arches built under my direction for the New York Building Department tests, were put in in the usual and customary manner, without unusual care or ramming, with absolutely correct proportions of materials and without any attempt at building structures better than the average. In this I refer to two Roebling floors and one each of the Rapp, Thomson and McCabe floors.

The only tile floor which was not seriously injured by the fire test, although from this one several tiles fell out, was the Guastavino; this is a true arch construction of flat slabs of tile braced by independent ribs of flat tile, but one-half of this was reinforced by a complete concrete arch of sufficient strength to carry the entire load. It is a question in my mind whether the Guastavino tile arch would have withstood the test successfully had this concrete been omitted. The tile structure described in Engineering News of Sept. 17, 1896, was tested in October, and in less than three hours' duration of a fire just reaching 2,000° F., the tile arch collapsed, while the adjacent Roebling concrete arch remained intact with its superimposed load of 10,000 lbs. placed on the middle 2-ft. square.

There can be no question that in the Pittsburg fire all of the structures were subjected to intense heat, and the Methodist Publishing House showed this in its upper stories most clearly. The fact remains that many of the tile arches and tile column protections failed completely, while none of the concrete arches, although of far greater spans, showed the slightest sign of failure.

The advocates of tiles recognize this difference, but are leaving nothing undone and unsaid to contradict it, because they are well aware that long-span floor arches—over 7 ft.—are practically impossible to construct of tile be-

cause of their very great weight and expense. In the manufacture of tile the number and size of molds and machinery must be kept at a minimum or else the cost of manufacture will increase at such a pace that tile cannot compete with other materials. If the columns in the Pittsburg fire had been properly protected by concrete instead of tile and plaster, they would not have become as exposed as the photographs show to have been the case. Concrete arches can be built as monoliths to cover the lower flanges (soffits) of iron beams much more readily than can be done with tile, and there is little liability of its falling off, as was shown by the Thomson test (Eng. News, Nov. 12, 1896).

The tile partitions in the Horne Building were completely demolished, as is invariably the case in such fires (see Eng. News, April 13, 1893, Temple Court fire), even when temperatures are not very high.

In view of all of this various testimony, without even referring to the numerous fire-tests which have been made in Europe, it must be apparent to any unprejudiced observer that concrete is incomparably superior to tile construction, in spite of the illogical stand maintained by the Board of Examiners of the New York Building Department. When it is further remembered that the Building law of New York city, in its present form, was inspired mainly by persons now members of that board, it will become apparent why the peculiar wording is adhered to that gives the board such arbitrary and great powers.

In reference to Mr. F. C. Moore's letter (Eng. News, May 27, 1897) I desire to call attention to his statements in detail, for they show that he is an inveterate opponent of every form of fireproof floor construction except brick and tile. This appears from his first utterance after quoting the law, where he says: "I do not believe any of them, however, equal to a brick arch, and whether or not they are equal to a sectional tile arch with skewbacks provided with lips for protecting the soffits of iron beams, is a question as to which experts differ."

In this statement Mr. Moore, who is an insurance man, gives experts' opinions, the value of which are apparent. All experts know that brick arches do not protect the lower flanges of iron beams, and that a lateral load is destructive, especially during action of high temperatures. Moreover, it has been conclusively demonstrated that the so-called soffit tiles supposedly protecting the iron skeleton, were invariably the first parts to fall, and are moreover rarely used, being awkward to insert and easily broken. (They can only be used when the width of bottom flanges is just right, and the use of filling cement, as is claimed, does not overcome the difficulty.)

Mr. Moore begs the question when he says that it is the duty of the Department of Buildings to see that only good materials are to be used, for he fails to see or does not know that it is very much easier to put in concrete of sufficient strength in floor arches than to control the quality and manner of constructing tile arches. Once tile arches are in place, they cannot be readily examined for either quality of material or workmanship; while in concrete floors a crowbar will at once test the strength in many places, without doing any damage. This is impossible with hollow tile. Actual tests in buildings in the city have demonstrated that even concrete arches laid in freezing weather are more than amply strong. The matter of freezing is against tile rather than concrete, because in freezing weather cement is used in very thin sheets between tile full of frost, while in concrete, which is always used in large masses, hot water and sand can readily be used to counteract frost. But Mr. Moore ignores these evident facts.

Mr. Moore's assumption that concrete cannot be laid in ordinary work as well as it was laid in the test structure, is based on lack of knowledge and is incorrect.

One reading his statement is led to believe that he was present at these tests, while I know from personal observation that as a matter of fact he was NEVER present while any of the concrete was laid in the structures, and was frequently absent from the tests themselves. In fact, when these tests were inaugurated the Board of Examiners opposed them and also refused to have anything to do with or to recognize them as official tests.

Now, while Mr. Moore in his letter claims to have done his full duty towards the citizens of New York, by familiarizing himself with modern fireproof construction, it nevertheless appears that he evaded his manifest duty when the first and only opportunity was offered to learn all about the best and most desirable forms of construction, by absenting himself wilfully on several occasions from these tests, and then deliberately voted against the use of concrete floors in buildings in spite of their successful passage of the tests.

Chief Bonner is the only exception to the above. He always visited each and every test structure, after test carefully examined it, and—said nothing; but even he did not see the concrete laid in any case that I can remember.

Mr. Moore again says that by "the various fire tests . . . it has not yet been demonstrated (for only experience can demonstrate the fact) that the iron will not rust out in course of time." Now, if Mr. Moore had attended these official tests, as was his manifest duty to do to enable him to perform his duties with intelligence, he would not now make such random statements. He does not yet know that the iron "falsework," or network on which the concrete is laid, forms no material part of the strength of a concrete floor. In the Roebling, the Rapp, the McCabe, the Clinton Wire Cloth, the Thomson, and other concrete floors, the iron may be entirely removed after the concrete has set without in any manner weakening the floor. Had Mr. Moore attended these tests he would have seen that the iron had been entirely burnt out (or at least its effectiveness had been entirely destroyed) in most parts of these structures (in the Thomson there was no iron at all), and the final test loads were carried even up to an equivalent of 8,000 lbs. per sq. ft. in the case of the Roebling, without the slightest sign of weakness.

Mr. Moore again poses as an engineer expert in the paragraph closing with the words "which need weight to insure stability against wind-pressure, etc." He displays his unfamiliarity of the actual methods of design and construction by these statements, and they are incorrect. Properly designed structures are braced in themselves, and need not be held down by an unnecessary weight of floor material. Think of the absurdity of this proposition, when the entire stability of our structures depends upon foundations and rigidity of framework. Did any competent engineer ever seriously assert that, say, 10 ins. depth of hollow tile on each floor had exerted material influence on lateral stiffness; or, that a building in a city ever had to be anchored down to be prevented from being blown over?

If the Board of Examiners, and Mr. Moore particularly, were to devote more attention to use of frequent firewalls and fire stops, (in London they are placed 20 ft. apart), great fires would rarely occur. Look at our large department stores, having floor areas up to 200 × 400 ft. without a single wall or fire-stop, and crammed full of inflammable materials. What a holocaust and conflagration would there be should one of them ever take fire! Let engineers decide upon materials for floor construction and insurance experts pass upon matters properly within their knowledge.

Mr. Moore asserts that the supervision of the Building Department is ample to exclude bad tile, brick and cement, and also to control the workmanship, which is of the greatest importance; but in the next breath he states that this same supervision cannot be trusted to detect bad cement, sand and workmanship in concrete work, or to stop work in freezing weather! How absurd and contradictory is such a position, yet, he asserts that the entire stand taken by the Board of Examiners is based thereon. It is clear from the above that the present position of the Board of Examiners is illogical and indefensible, and it is in order therefore to inquire what motives actually control this body.

Gus. C. Henning.

220 Broadway, New York city, June 14, 1897.

Notes and Queries.

H. M. writes: "I have heard for several years past that stone arch culverts built of inferior stone have been coated on their soffits with Portland cement to protect them from further disintegration. I have been unable to secure any reliable information as to the success of such treatment. If you can put me in correspondence with some one who can furnish the results of the above practice, it will be greatly appreciated."

J. J. W. asks if any one can report experience in the use of lime in filling trenches where it is especially necessary that no settlement shall occur. He has heard that by placing unslaked lime in the trench as the dirt is backfilled into it, the swelling of the lime, as it becomes slaked, is sufficient to neutralize the settlement of the back-filling.

THE RELATION OF CIVIL ENGINEERING TO PROGRESS.*

By Benjamin Morgan Harrod, Pres. Am. Soc. C. E.

In 1881 the American Society of Civil Engineers held its annual convention in Montreal. The President, the late James B. Francis, in the opening of his address, took occasion to say that the membership was then 636, and that "the most interesting event to the Society, since the last convention, had been the purchase of a house, in the city of New York, as a permanent home, at a cost of $30,000.

It affords me pleasure to be able to state on our return to Canada, after 16 years, that our membership has increased more than three-fold, being now 2,058, and that we have, during the past year, made arrangement for securing another "permanent home" at six times the cost of the present one. This, we hope, in a reasonable time, again to outgrow.

I shall endeavor on this occasion to present a brief view of the relations of civil engineering to the progress of the present time and country; of its opportunities and limitations, and of the responsibilities and duties of our Society; together with such suggestions as occur to me for promoting its prosperity and influence, as the national exponent of the profession.

The growth of our country in extent, numbers, wealth and comfort is more largely due to the civil engineer than to any other of her citizens. His work has made possible the occupation of the entire continent by cultivated and prosperous communities. Without the post-road, the canal with its incline planes and locks, and then the railroad with its bridges and tunnels, Americans would still be lingering, "a feeble folk," along the Atlantic seaboard, with the Appalachian chain for a barrier, crossed only for curiosity or adventure.

The new demand for the services of the civil engineer is due to the extension and greater complexity of the social organism, and requires for its supply more varied scientific knowledge. Its field includes the manufacture of power from new sources, air, gas, electricity, and the contrivance of new tools for its utilization. It calls for better sanitation, ventilation, heat and light; the improvement and cheapening of all processes of manufacture; the application of power in small units for domestic purposes, and its accumulation in great central plants for commercial distribution; for more rapid transit, both in municipalities and for great distances; for longer bridges, higher buildings and faster steamships; for deeper rivers, harbors and lakes, and for stronger levees.

If this estimate of what the civil engineer has already done and has still to do for the future development of this country is reasonable, such an occasion as the present is opportune for the consideration of the means by which our duties to ourselves and the public can be best performed, and wherein they can be promoted by this Society.

The attempt has been made by some professions, which have had sincerely in view the public and private interest, to attain these objects, and, at the same time, defend themselves against the Bashibazouks of the calling, by protective legislation. I believe that the experience of the past, in this direction, has not been encouraging, for, on the one hand, the public is disposed to view any such measure with a suspicion and resentment which would be likely to thwart its benevolent intention, and, on the other, the advancement of science is no longer an infant industry, needing protection against the waning powers of ignorance and pretension. It will be more satisfactory, in the long run, if the struggle for existence is allowed to go on, the engineer acquiring his status by hard work, and the people their experience by hard knocks, in order that adjustment may be final and permanent. The tendency is now towards the accomplishment of the same ends of a higher education, more scientific work, and closer personal and professional co-operation among members. In evidence of this is the increasingly thorough and extended courses in the better class of profession schools, the more general employment of trained engineers, and the growth of scientific societies in influence, activity and tone. The School and the Society, rather than the Legislature, are the tools we need for working out our professional salvation.

The same thought may be applied to what are called "Codes of professional ethics." Of course, a strong and cultivated moral sense, of which the Golden Rule forms the larger part—absolute good faith and fidelity towards all men and particularly among fellow-workmen—is the foundation of all social and professional relations, being, perhaps, stronger and more necessary among engineers, in proportion as their responsibilities to the public and to each other are greater than in some other vocations. But this must be a plant of natural growth, with roots deep in the moral nature, made strong and hardy by exposure to the vicissitudes of life, and kept green by professional good-fellowship. A code which has to be proposed, and seconded, and debated, and amended, and passed by a majority vote, can hardly be counted on for the necessary virility in the time of trial. If the principles of such a code met with general acceptance there would be no occasion for its formal adoption. If they were not so accepted, its enforcement would be a matter of doubt and difficulty. If it were not uniformly enforced, a righteous expression and effort would fall into contempt, a desuetude which would not be innocuous, and the last state of that profession would be worse than the first. The prevalence of social order and the progress of humanity and culture is more largely the result of a trained and enlightened public sentiment than of all the laws and all the courts, and its influence will afford the surest reliance in the conduct of our public and private relations.

Since organized co-operation among the members of a profession affords a stimulus for interest, and an opportunity for the increase and systematization of learning, which is essential for the freest development of the applied sciences, this century, in which the progress of the learning on which these sciences is founded, and the increase of the uses to which they are applied, has been unprecedented in the history of the world, has therefore been specially marked by the birth and growth of scientific societies of all kinds. It was but natural that civil engineers should take a very prominent part in this movement, impelled by the necessity for a more complete organization of their department of knowledge, and the desire for a common ground on which to meet to compare results and collect information for future generalization, and establish kindly personal and professional relations. The lawyer, the doctor and the clergyman—unless he happens to be a missionary—find the scene of their labors where population is concentrated, where their fellows are their neighbors, where libraries are accessible, and an atmosphere of culture and learning prevails. On the other hand, a

*Condensed from the President's address at the annual convention of the American Society of Civil Engineers, at the Chateau Frontenac, Quebec, June 30, 1897.

large part—and particularly the earlier part, when the social instinct is strongest—of the lives of many engineers is passed without these advantages and alleviations. Hence, engineering societies, supplying a want otherwise unsatisfied, are numerous and prosperous, and the good civil engineer is apt to be a good society man.

The distances across our country are magnificent, and we, in large proportion, are stationed at the outposts. Frequent resort to a single and far distant center is extremely difficult for men whose employment is so exacting as that of the civil engineer, and therefore, many are compelled to forego, to a great extent, if not entirely, those opportunities of social intercourse which the society is designed to promote and which, as experience has showed, contribute largely to the success and interest of professional life. The general recognition of the necessity for social and professional organization for the advancement of the work and interests of civil engineering, combined with an experience of the limitations which are imposed on some of the functions of a national society by the differentiation of the special departments of study and practice, but more especially by the extent of the field over which its members are scattered, has created a natural demand for full and equal participation in all the benefits which organization can confer, and has led to an increase in the number and prosperity of local societies which substantially promote the growth of scientific knowledge, interest and good fellowship.

This specialization of work and interests which has led to this subdivision of the profession on topical and local lines, must therefore, not only be accepted as part of the natural trend of events, but also acknowledged as an important factor in engineering progress. But it surely involves a tendency towards partial development, and to that extent, is accompanied by serious peril of atrophy or degeneracy. It might appear, at first sight, that the greatness of both the country and of the profession were obstacles to the adequate development of a national society. On the contrary, the conditions which I have recited are both reasons and incentives for averting this peril by an organization whose chief function is the maintenance of the unity and dignity of the profession by the advancement of that general engineering knowledge upon which the successful practice of all its branches is conditioned, and by strengthening the ties of fellowship among American engineers.

Under these conditions, a national society is not only a part, but the head and front of a great system, founded on the necessity for general scientific culture and the fellowship of American civil engineers. It bears the relation to other societies that a university does to a college. It should supplement and round out the work of those societies which specially pursue one branch of learning and practice, by making its prominent function the presentation and illustration of the general truth of engineering science, which is the root and trunk from which all the branches spring.

It represents the Federal idea, and should lead the special and local societies, not only to closer union among themselves, but also with a central institution, with the bond of a common object—a love for all knowledge which is included in the constantly broadening definition of civil engineering, and of kindly professional feeling and intercourse.

The subject of a closer alliance between these organizations than at present exists, has on several occasions received consideration, leading to the conclusion by both parties, that the conditions favorable for such a measure did not then exist. They probably do not now exist. But it seems to me that the proper mental attitude on this subject is to recognize as a fact, that some such alliance is natural and desirable; and to seek to promote the conditions which will make it, at some future time, practicable. This view leads to no contention, as persistence in the traditions and policy which have already given to this Society its great measure of success, together with the general pressure for higher education, are the most certain means of bringing about such conditions.

The expediency of steadily raising the standard of membership is so obvious that it is hardly a subject for discussion. It is rather a part of the general movement of the times for the advancement of learning. On the one hand the preparation for practice is becoming more difficult from the increase of knowledge, and the duties more exacting from the enlargement of the field of civil engineering work and the variety and magnitude of its problems. On the other hand the professional schools are, year by year, sending out men better equipped and trained for work. So the forces are applied from different directions, and are determining the path this Society must follow, if for no higher reason than to keep in touch with the times.

An engineering society, in the selection of its members, cannot follow strictly academic or doctrinaire lines. They may come from the schools, or from other and opposite directions. The men who have been drawn into the profession by an irresistible impulse of genius rather than by a carefully regulated training have done their full share in raising civil engineering from a mechanic art to one of the most scientific and useful of professions. It must have a welcome for all who can give satisfactory answer to the questions: What have you done? What can you do? Room must be made for those who have either attained eminence by general practice and learning, or in some special branch of engineering science; for those who conceive and promote great enterprises, and those who elaborate the methods and details; for those who organize the plant and labor, and assume the responsibility of their prompt and economical performance, and those who enforce their specified execution; for those who administer and develop transportation and manufacturing enterprises already established; for those who improve our rivers, harbors, mines, and alluvial and arid lands; for those who build our land and sea defences; for the scholar in engineering, and for him who has been led, by strong natural faculties, to follow the calling of a civil engineer.

Since the prosperity of the Society is so entirely dependent upon the character of its members, it is important that the machinery of election should be of the most perfect kind. With this object, I believe that certain changes in that part of our constitution regulating elections, which are in the line of the experience of other large associations for social, business, or scientific purposes, should receive consideration. The present system of proposal and investigation, the Membership Committee and the Blue List, is entirely good. But after them, it remains in the power of those who have not seen fit to express any objections they may have, on the opportunity afforded by the Blue List, or of those whose reasons may not have appeared sufficient to the Board of Direction, to render a verdict of such importance that a prudent man may well hesitate before he accepts the risk, no matter how well he may be qualified. A more serious view is that the present method may occasionally admit of the infliction of wrong or injustice. I believe, for these reasons, that the responsibility of final election could be entrusted to the Board of Direction with benefit to the Society.

The chief function of an engineering society is the preparation, discussion and publication of professional papers. They constitute the reason for its existence, and its claims to consideration. With us they fill the place of the annual reports of decisions with lawyers, with the advantage that, if we do not like the precedents they establish, we are at liberty to improve them.

The Transactions of the American Society of Civil Engineers are the record of the history of American engineering, and in its list of contributors are the names of those men who have made this history. These volumes are the foundation on which the high character of the Society rests, and by their increase in number and value will the progress of engineering learning and the welfare of the profession be best assured. The importance of this part of the work of the Society imposes a duty on every member, while he is afforded the privilege of access to an audience which he can reach in no other way than by its discharge. The appeal is thus to professional pride and self-respect, and to loyalty to the Society and his fellow members.

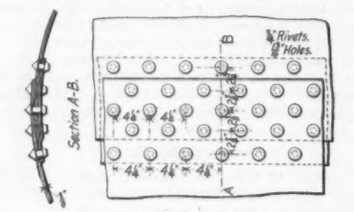
The occupation of the New Society House will give opportunity for the development of the library both in extent and usefulness. The proposed arrangements for stacking and reading are excellent. Whether the library is hereafter to be open to the public, to all seeking information on engineering topics, or is to be a private storehouse for such knowledge, is a subject which seems to me deserving of very serious consideration. The happiest solution would combine both access for the engineering public, and extended special privileges to members.

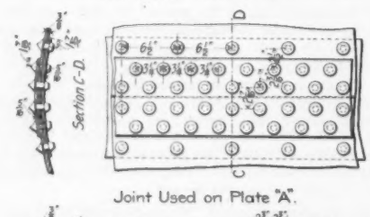
Among the benefits of membership should be the opportunity of conveniently and cheaply securing, by correspondence, an abstract or summary of engineering literature on any point or subject, so far as it may be contained in our library. I believe that this system would meet a reasonable want of many members, for engineers generally have not the constant opportunity of collecting or consulting books that belongs to the more sedentary professions. This system would involve an expense for which, at present, the Society may not be prepared, and at the beginning sufficient fees to cover the cost of the service might be required. But as the system and the Society prospered, the application of a part of its revenues to the reduction of these fees would be a proper and legitimate expenditure for the promotion of the main object of the Society, the increase of engineering knowledge among its members.

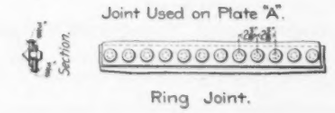
It would also be a proper subject for consideration, and, perhaps, of experiment, to ascertain if a system of loaning books to members, under certain restrictions, secured by deposit, or otherwise, could not be devised, with a gain to learning more than commensurate with any loss or trouble that might be incurred. The more modern museums freely lend specimens to responsible naturalists, and, while there is, of course, a certain danger of loss, the advantage to science, through the opportunity of investigation thus afforded, more than counterbalances an occasional mishap.

EXPERIMENTS IN BURSTING A BOILER BY HYDRAULIC PRESSURE.

An interesting series of experiments was recently made in St. Louis to determine the ultimate resistance of the cylindrical shell of a horizontal tubular boiler to hydrostatic pressure. The boiler tested is illustrated in the accompanying cuts. It was built by the John O'Brien Boiler Works Co., of St. Louis, at its own expense, especially for these experiments, the object being to determine the strength of two different styles of riveted joints. One of the joints was what is known as the double welt butt joint, and the other was a lap joint with single welt on the inside. There is nothing new about either joint. The lap joint has been used in locomotives and other places where a strong joint is needed. The steel was purchased in Pittsburg, one part from one mill and one part from another, and it was the usual stock used in

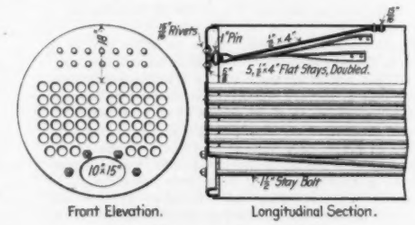


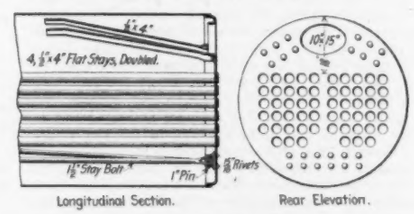


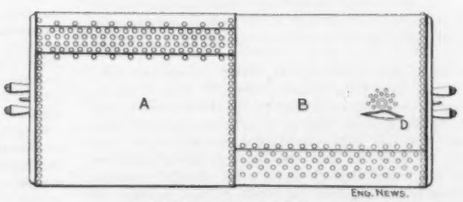


HORIZONTAL TUBULAR STEAM BOILER TESTED BY HYDRAULIC BURSTING PRESSURE.

Manufactured by the John O'Brien Boiler Works, St. Louis, Mo.







boilers of the brand known as "Flange Steel," stamped "60,000 lbs." tensile strength.

The diameter of the boiler was 60 ins.; length, 12 ft.; shell, ⅝-in. thick; heads, ¾-in. It had 56 3½-in. tubes, and was jointed and braced as shown in the drawings.

The tests were made at the John O'Brien Boiler Works, under the direction of Mr. William W. Corry, U. S. Inspector of Boilers, and in the presence of Mr. Chas. J. Price, City Boiler Inspector, and several other engineers, including Messrs. H. C. Tulley, Member Board of Engineers, city of St. Louis; A. B. Ecott, Chief Inspector, Hartford Steam Boiler Inspection & Insurance Co., and Geo. W. Smith, Jr., Chief Inspector Fidelity & Casualty Insurance Co., of New York.

The accompanying table summarizes the results of the tests:

Taking the bursting pressure at 900 lbs. per sq. in., the diameter 60 ins., and the thickness of the shell ⅝-in., we have: Tensile strength = pressure × diameter ÷ twice thickness, or 900 × 60 ÷ ⅝ = 72,000 lbs. per sq. in., which is 20% greater than the strength stamped upon the steel plates. It is evident that the steel must have been considerably stronger than 60,000 lbs., but the result of the test shows that the design and workmanship of both styles of riveted joints must have been excellent or they would have parted or at least leaked before the shell had expanded to the extent shown in the record of the tests. It will be noted that the joint with five rows of rivets yielded slightly more than the joint with six rows, as was to be expected.

Hydraulic Bursting Tests of a Steam Boiler.

Hydraulic pressure, lbs. per sq. in.	Expanded. Ring B, ins.	Ring A, ins.
Test No. 1, March 29, 1897.		
300	1⅝	2⅝
450	2⅝	3½
750	3¼	5
Test No. 2, April 4, 1897.		
625	3⅝	5⅜
Test No. 3, April 5, 1897.		
350	4 1-16	5½
400	4 1-16	5½
625	4 7-16	No change till rupture.

At 900 lbs. pressure boiler ruptured at point D, the feed pipe opening.

THE CAUSE OF THE BAD TASTE AND ODOR OF THE BROOKLYN WATER IN 1896.

An exhaustive report on the causes of the bad taste and odor of the water supply of Brooklyn in the summer of 1896 has just been made public. The examinations and report were made by Dr. Alfred R. Leeds, of the Stevens Institute of Technology, assisted in the biological work by Mr. George C. Whipple. The conclusions presented by Dr. Leeds are so interesting and so clearly and briefly stated that we reprint them below, practically in full:

The objectionable appearance, taste and odor of the Brooklyn water during midsummer last and later periods has been principally and essentially due to the microscopic plant-growth known as the Asterionella. It resides in the distributing reservoirs at Ridgewood and Mt. Prospect, and more especially in Basin No. 3 of the Ridgewood reservoir and in Mt. Prospect reservoir. Its origin has nothing whatsoever to do with artificial causes like drainage, sewage or contamination. It is entirely due to purely natural causes, the first being the microscopical chemical constituents of the water, and the second, and even more important, being the physical conditions in which the water is placed after entering the reservoirs. The important questions, therefore, to consider, are:

(1) What is the Asterionella, and what is peculiar about it? (2) What is there in the composition of the Brooklyn water, or the mode of handling and storing it, that has fitted it especially for the development of the Asterionella? (3) How can the growth of this organism be prevented?

In answer to the first question, it may be said that the Asterionella derives its name from its form, being a star-shaped organism usually 8 or 4-rayed. (See accompanying reproduction of illustration given in the report.—Ed.) It is a Diatom, that is an alga, which is distinguished from the other algae by being enclosed in an envelope or capsule of silica. This particular genus of Diatom has also the further peculiarity of secreting a substance in the nature of an oil which possesses a taste and odor so characteristic that, for lack of a better name, I have elsewhere designated it as the Asterionella flavor. It is a combination of fishy, salty and oily taste, its odor strongly resembling that of certain varieties of geranium.

Although some of the samples of the reservoir water No. 3 contained as many as 20,000,000 individual Asterionella to the gallon, yet it would require many hundreds of gallons of water to get enough of the oily product which imparts the taste and odor to work upon in the laboratory and accurately determine its nature. In many of its properties it resembles trimethylamine.

In the month of August, when the trouble was at its worst, the water had a white appearance and was filled with minute white threads. On standing, it threw down a flocculent deposit of a stringy, whitish or yellow-white matter. Under the microscope this deposit was found to consist of innumerable Asterionella matted together with other diatoms, strung together in threads, the other diatoms being more especially the Melosira, Tabellaria and Synedra. These thread-like forms have not been noticed to produce the objectionable taste and odor secreted by the Asterionella, and, moreover, they were vastly less abundant.

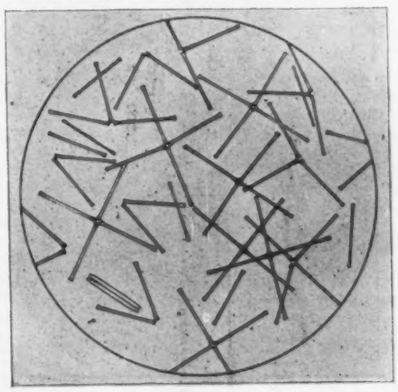
The water itself was colorless, the apparent color being due to the suspended organisms and their products.

The oily taste-producing substance is volatile and cannot be gotten rid of by distillation. It distils over with the steam, giving to the distilled water a faint whitish appearance or opalescence, and communicates to it the same characteristic taste and smell.

Neither can it be gotten rid of by filtration through paper or cotton or a thin layer of sand. Sand will arrest nearly all the Asterionella and then on being washed with pure water, the water used in washing and containing the Asterionella will be found to have taken up the taste and odor. To remove, however, both the Asterionella and all the taste and odor arising from it, it is necessary to filter through animal charcoal, or through a properly constructed sand filter of sufficient depth.

(2) What are the peculiarities which render the Brooklyn water especially fitted for the development of this organism?

In answering, it should be noted, in the first place, that the most characteristic feature of the diatom is its envelope of silica. There are many other kinds of micro-



Asterionella in Brooklyn Water Supply, Magnified 1500 Diameters.

scopic organisms represented in the different portions of the Brooklyn water supply, such as the green algae, the bluish-green algae, the fungi, the Rhizopods, Rotifers, Crustaceans, etc., but none of these are characterized by the presence of silica, and of course do not in the same sense imperatively demand it as a constituent of their food. Moreover, the number of these non-silex-secreting organisms is insignificant when compared with the stupendous numbers of Diatoms.

Such being the case, there must be a great abundance of dissolved silica in the Brooklyn water, and something in the nature of the watershed which enables it to impart the silica.

As a matter of fact, the ponds and streams contributing to the Brooklyn supply have sides and bottoms of sand which is silica in an undissolved form; the 822 shallow wells contributing to the supply are sunk to a depth of over 40 to 70 ft. to a strata mostly composed of silica, and the 107 deep wells contributing to this supply go down through 140 to 150 ft. mostly of the same material.

Moreover, all the water has an alkaline reaction and is capable, therefore, of dissolving silica and holding it in a soluble form. The wells, indeed, are the chief source of silex in the Brooklyn water. The complete analysis of the mineral constituents given later shows that the wells contain 1.5 parts per 100,000 of silica. By dilution with the surface waters containing relatively less, the silica in the combined supply is only about half as much. But even then it amounts to 9% of the total mineral matter present. This large amount is more than ample for the nutriment of the enormous number of silicious algae which thrive and multiply in the Brooklyn reservoirs and distributing mains. Where do these diatoms come from?

In answer to this question Dr. Leeds states that in the water from shallow wells the Asterionella were found but once, and then only two individuals were present. In the surface waters the organisms were found but seven times, the highest number here being only 35. The water from the reservoirs showed far different results, except at the influent pipes, where, on Dec. 23, for instance, Basin 3 showed none of the organisms. But on the same day water from the center of this basin contained 6,400 Asterionella per cu. cm. (2,560 units).*

The further statement of the number of Asterionella found in this basin and in the Mt. Prospect reservoir is as follows:

The sample taken from the center, but at the bottom of the reservoir, at the same time, contained 11,616 Asterionella (4,646 units), the sample taken from the efflux at the same time contained 9,552 Asterionella (3,821 units). The same comparison made on Jan. 11 showed that as the water flowed into Basin No. 3 it contained no Asterionella; as it flowed out it contained 7,518.

In the water of the Mt. Prospect reservoir, Nov. 4, there was at the efflux 12,020; Nov. 5, 17,720; Jan. 11, 17,280; Jan. 18, 15,160 Asterionella.

In Basins 2 and 3 of the Ridgewood reservoir the Asterionella were not found in some samples and in only very small numbers in others.

Dr. Leeds' comment on the fact is given below, followed by the balance of his conclusions:

It is evident that these vast numbers of Asterionella developed in Basin No. 3, during the very brief period after the water came in and before it flowed out. The same remark is true of Mt. Prospect reservoir, which is principally supplied from Basin No. 3. The reasons why Basins Nos. 1 and 2 contained relatively so few diatoms are discussed in extenso in the appendix. I will simply remark here that these two basins are more especially supplied by the water from the deep wells, and that the deep well water is characterized by an almost entire absence of micro-organisms.

Besides the silica what else in the way of food do the diatoms require? Multiplied observations in many other localities have shown that such a stupendous development of diatomaceous growth as the reservoirs exhibited last summer is possible when there is present an abundant supply of food in the form of assimilable nitrogen. The accompanying tables of analyses exhibit the nitrogen in two forms: One as organic nitrogen, that is, nitrogen in the non-oxidized condition, in which condition it is not available as food. This organic nitrogen is represented in the analyses by the so-called albuminoid ammonia. The other form is inorganic nitrogen (the so-called free ammonia, nitrites and nitrates), in which the nitrogen is oxidized, and can at once be appropriated by growing plants as food.

In Table No. 1 (tables omitted.—Ed.) I have given the average composition in pounds, as deduced from analyses made during the course of this report, of the sum total (amounting to 82,000,000 gallons) of all the surface, shallow and deep well waters, before they go into the reservoirs; then of the same 82,000,000 gallons as they are supplied from the reservoirs; and lastly their composition as supplied from the city taps. The first shows the presence of 835 lbs. of nitrogen available as food, or oxidized nitrogen, and 39½ lbs. of nitrogen not so available. In the reservoirs the food nitrogen has been cut down to 718 lbs. and in the tap waters to 633 lbs. The superabundance of food for the microscopic organisms has been in part used by them, and is represented by their vastly increased numbers in the reservoir and tap samples, as compared with their numbers in the surface waters and in the wells. The trasformation has been mainly effected during the brief interval in which the waters remained in the reservoirs.

But why should this transformation and the immense multiplication of the Asterionella take place in the reservoirs, and not in some pond or stream where Asterionella are also found, and where abundance of food is likewise present? To explain this fact it is necessary to have recourse to what is known of the habits of life of the Asterionella in cases where its enormous multiplication, along with the phenomena of nauseating taste and odor, have been observed. Its multiplication is essentially favored by abundant access of light; by a gentle, tremulous motion of the water; by the absence of peaty or other coloring matter in the water, and by storage in shallow reservoirs. All these conditions exist in an eminent degree in the Brooklyn reservoirs. Together with the kind and quantity of the food, they are ample to explain what occurred in an aggravated form last summer, what is observable now, although to a far less extent, and what will occur at different seasons in the future until the physical conditions that render the occurrence possible have been removed.

So far as I know the only remedy that has proved effectual has been that of excluding the light, and converting the reservoir into a substantially subterranean basin.

The proposal to aerate the water, which was advocated in some quarters last summer, was, fortunately, not entertained. The writer speaks with the more positiveness upon the subject, inasmuch as he introduced the mechanical aeration of water supplies, and has seen its in-

*Units are used to compare various classes of organisms of different sizes.

troduction followed by the happiest results in cases where conditions favorable to stagnation were dominant. But the reverse of such conditions exist in the present instance, and the aeration of water in the Brooklyn reservoirs, with its accompanying large expense, would have resulted only in intensifying the trouble.

Filtration of the waters before they enter the reservoirs will not answer. Filtration of the entire supply before pumping it into the reservoirs would be an exceedingly costly and by no means a certain cure. It should be borne in mind that of the 82,000,000 gallons supplied, the 46,500,000 gallons coming from the wells may be looked upon as water which has already been filtered. After water has been filtered if any of the micro-organisms escape the action of the filtration and find their way into the reservoirs, their propagation under favorable conditions takes place more rapidly in the filtered than in the unfiltered water. And what is most important of all, the number of Asterionella found in the ponds and streams is relatively so small that in the samples I took for examination of the water as it came into the reservoirs, I found in no instance this particular organism, the Asterionella, which is the chief cause of the trouble.

If filtration is applied it should be as they go out of the reservoirs, and it should be used without subsequent storage, both of which expedients would prove more costly and more unsatisfactory than that of covering the reservoir.

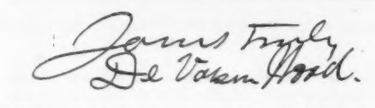
In all that I have said above, I have not forgotten that other organisms, like the Uvella and the Dinobryon, are capable of producing disagreeable tastes and odors, and that the decay of infusoria, etc., has had some effect. But these organisms are relatively so few in number that their influence has been insignificant in producing the troubles observed in the Brooklyn waters. The same remark is true of the presence of sewage. While sewage impurities have entered the supply from Springfield Pond, Hempstead and other localities, and these impurities should be cut off with least possible delay, they have not produced the tastes and odors complained of. It should also be stated that the oily substance secreted by the Asterionella has not been known to be the immediate cause of any sickness more serious than that of the nausea connected with its disagreeable taste and odor. Yet till its growth is prevented, all the expedients which may be resorted to in the cleansing of ponds, diversion of sewage, etc., will not result in delivering to consumers the excellent water which the wells and ponds of the Brooklyn water system naturally afford. I should recommend that the covering of the reservoirs should begin with Basin No. 3. On the continent of Europe and in England the covering of reservoirs, which is a very general and growing practice, is effected by building parallel walls of masonry and capping them with brick arches. These arches are covered over with sand and earth to the depth of several ft. and the top surface converted into a lawn with grass and flowers. In this country the construction has been made less costly by the substitution of piers of masonry, instead of walls. Inasmuch as the rigor of our winters and the greater development of algae growths during summer in our reservoirs, as compared with those of Europe, make their coverings even more imperative, there can be no doubt that the element of cost, which is the chief obstacle, will presently be greatly lessened by the introduction of new engineering devices.

Dr. Leeds' report is prefaced by an outline of the water trouble last summer presented by Mr. I. M. de Varona, M. Am. Soc. C. E., Engineer of Water Supply, who brings out the significant fact that the water in Basin 3 was drawn down to a depth of 9 ft. before the trouble began in order to make a new pipe connection with the basin. This was done by another branch of the water service, "against the express misgivings" of Mr. de Varona. Mr. de Varona recommends the construction of a by-pass in order that the water need not be exposed to the light and air during the development of Asterionella or other objectionable life in the reservoir.

DE VOLSON WOOD.

De Volson Wood, professor of mechanical engineering in the Stevens Institute of Technology, died at Hoboken, N. J., on June 28, of paralysis of the heart following an acute attack of diabetes. His death removes one of the best-known and most highly respected American engineering teachers and authors, and is the first death in the faculty of Stevens Institute since its organization in 1871 except that of Col. Haskell, his predecessor, who served only during its first year and died shortly after his retirement. He was engaged in teaching in engineering schools for about 40 years, having been professor of civil engineering in the University of Michigan for 15 years before he came to Stevens Institute, where for 13 years he was professor of mathematics and mechanics and for 12 years professor of mechanical engineering. He was also the author of the following well-known mathematical and engineering treatises and text books: "Trusses, Bridges and Roofs," 1872; "Revised Edition of Mahan's Civil Engineering," 1873; "Resistance of Materials," 1875; "Elements of Analytical Mechanics," 1876; "Co-ordinate Geometry and Quaternions," 1879; "Trigonometry," 1885; "Thermodynamics," 1885, enlarged 1889; "Turbines," 1895. He contributed articles to "Appleton's Cyclopedia of Mechanics" and "Johnson's Cyclopedia," and to the transactions of various engineering societies. He was a member of the American Society of Civil Engineers from 1871 to 1885, of the American Society of Mechanical Engineers from 1886, of the American Association for the Advancement of Science from 1879, being one of its vice-presidents in 1885; of the American Methematical Society, honorary member of the American Society of Architects and a member and the first president of the Society for the Promotion of Engineering Education.

Prof. Wood was born near Smyrna, N. Y., in 1832. He attended the public school, was six weeks in a private academy and two terms in the Cazenovia, N. Y., seminary. He began teaching in Smyrna in 1849, remaining three terms, and his



subsequent education was obtained while he was teaching. He then went to the New York State Normal School, graduating in 1853, continuing work as teacher during his course. He then became principal of a school in Napanoch, Ulster Co., N. Y., and returned to the normal school the next year as associate professor of mathematics. In 1855 he entered the junior class in the Rensselaer Polytechnic Institute, graduating with the degree of Civil Engineer in 1857. During his course there he met his entire expenses by teaching mathematics in the preparatory department. After graduating he visited the University of Michigan at Ann Arbor and was requested by President Tappan to take the place for a few days of the professor of civil engineering, who had failed to put in an appearance. He remained there 15 years. During this time he organized the Department of Civil Engineering in the university and received the honorary degrees of Master of Arts and Master of Science from Hamilton College and the University of Michigan respectively.

In 1871, when the Stevens Institute of Technology was organized, he was offered a professorship, but the University of Michigan raised his salary and prevailed on him to remain. The next year the offer was repeated, and he accepted it. He continued there as professor of mathematics and applied mechanics, giving courses also in Resistance of Materials and in Roofs and Bridges until 1885, when he was called to fill the chair of mechanical engineering, vacated by the resignation of Prof. R. H. Thurston, who had received the appointment of Director of Sibley College, Cornell University. This chair he held until his death. During the last twelve years of his life he resided in Boonton, N. J., where he took a prominent part in public affairs, being a member of the Board of Education. He was also very active in church matters, and while residing in Hoboken he taught a Bible class on Sunday, which was largely attended, some of the students of the Institute being his scholars.

The funeral services were held in Hoboken at the residence of his brother, Prof. H. A. Wood, of the Stevens Preparatory School. It was attended by many of his former students, alumni of the Institute, to whom he had always been a kind counselor and friend. It was well said of him at the funeral, that he was a large man in every respect—in body, in mind and in heart. He was an ideal teacher, but the many hundreds of engineers who had the good fortune to be students under him will cherish in their memories more than they do his ability as a teacher the charm of his manner and his strong and noble character.

Prof. Wood leaves a widow, two sons and three daughters. His remains are to be interred at Ann Arbor, Mich.

THE WESTINGHOUSE HIGH-SPEED BRAKE.

The great increase in the speed of trains and in the number of fast trains, which has been a feature of the development of railway service in this country during the past few years, has led to a modification of the Westinghouse brake, which is specially adapted for high-speed trains, and which will make emergency stops of passenger trains in a distance about 30% less than that required for the best ordinary brakes. The superior stopping capacity of this high-speed brake is obtained by creating a pressure in the brake cylinders in an emergency stop, which is higher when the brakes are first applied than it is when the speed of the train is reduced. As is well known, the coefficient of friction between the brake-shoe and the wheel is very low when the brakes are first applied on a train moving at high speed, but rapidly increases as the speed slackens. The limit of what any brake can effect is of course the retardation which will slide the wheel on the rail, but the pressure on the brake-shoe at the moment of application can be increased to an amount considerably in excess of the brake-shoe pressure without causing sliding.

To secure this varying pressure in the brake cylinder the air pressure in the train pipe is increased from the standard 70 lbs. to a pressure of 110 lbs., and a pressure regulating device is attached to the regular Westinghouse quick-action brake equipment on both locomotives and cars. This device is all that is needed to convert this apparatus into the high-speed brake. It can be attached to any point convenient to the brake cylinder, to which it is connected by piping. This valve does not operate during service applications of the brake unless the brake-cylinder pressure rises above 60 lbs. per sq. in., in which case the valve will discharge enough air to bring the pressure down to 60 lbs. With an emergency application of the brake the violent admission of a large volume of air to the brake cylinder raises the pressure more rapidly than the reducing valve can lower it, and the service port of the valve is therefore partially closed, restricting the discharge of air from the cylinder in such a way that the pressure in the brake cylinder does not become reduced to 60 lbs. until the speed of the train has been materially decreased.

With the high-speed brake the pressure carried in the train pipe and auxiliary reservoirs is 110 lbs. per sq. in., and an emergency application will almost instantly fill the brake cylinders with air at 85 lbs. pressure, thus increasing the braking force from about 90% (the ordinary standard) to about 125% of the weight of the car, while the pressure of the brake-shoes upon the wheels is about 40% greater than with the quick-action brake. Two or even three service applications may be made without recharging the reservoirs and still leave sufficient air pressure to make an emergency stop

equal to that of the ordinary quick-action brake. Simple additions to the brake apparatus on the locomotive enable the train pipe to be easily and quickly changed to 70 lbs. pressure when the engine is put in another class of service.

Fig. 1 shows a vertical cross section and Fig. 2 a horizontal cross section through the slide valve

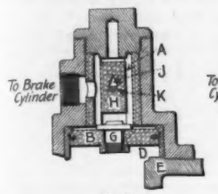


Fig.3.
Position of Ports.
Release.

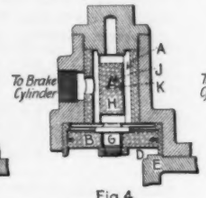


Fig.4.
Position of Ports.
Service Stop.
Pressure Exceeding 60 lbs in Brake Cylinder.

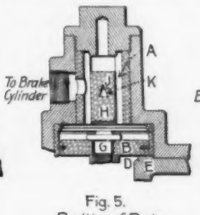


Fig. 5.
Position of Ports.
Emergency Stop.

AUTOMATIC REDUCING VALVE OF THE WESTINGHOUSE HIGH-SPEED BRAKE.

of the reducing valve, which is attached to some convenient point on the car or engine by its bracket, and is connected to the brake cylinder by piping thereto from the union swivel. Chamber A is at all times in communication with the brake cylinder, and piston B is subject to whatever pressure may be therein, while an adjusting spring, C, on its opposite side, provides resistance to its movement downward, which is limited to chamber D, or until it strikes the upper surface of spring case E. This resistance can be readily varied by adjusting nut F as may be required. Combined with piston B is its stem G, fitted with two collars, between which the slide valve H is carried and moved coincident with the movement of piston B when subjected to an air pressure from the brake cylinder which is in excess of the resistance of spring C. Slide valve H is represented by cross-hatched lines in Figs. 3, 4 and 5, and is fitted with a triangular shaped port, J, in its face, which is always in communication with chamber A, while a rectangular port, K, is arranged in its seat and is always in communication with the outside atmosphere at the exhaust opening.

In Figs. 1 and 3 the slide valve H and its piston B are shown in the normal position occupied so long as the pressure in the brake cylinder does not exceed 60 lbs. per sq. in. when used with passenger car brakes, or 50 lbs. when used with driving-wheel brakes, suitable adjustment for either pressure being made by compressing or releasing the tension on spring C. It will be noted that in this position port J in the slide valve H, and port K in its seat are not in register, and the pressure is therefore retained in the cylinder until the release of the brakes is effected in the usual manner.

When the pressure in the brake cylinder exceeds 60 lbs. with an ordinary service application of the brakes, the pressure acting on piston B moves it downward slightly until port J in the slide valve and port K in its seat are brought to register, as in Fig. 4. This enables the surplus air to be vented to the atmosphere, after which spring C forces the piston and slide valve to their normal position, as in Figs. 1 and 3, closing the exhaust and retaining 60 lbs. pressure in the cylinder. The area of ports J and K is such that they can discharge the surplus air from the brake cylinder to the atmosphere quite as rapidly as it enters the brake cylinder through a port in the slide valve of the triple valve of somewhat smaller area.

The position taken by the piston B and slide valve H, in an emergency application of the brakes, is shown in Fig. 5. The violent admission of air to the brake cylinder suddenly drives piston B throughout its entire traverse until it rests on the spring case E, when the apex of port J in the slide valve is brought into conjunction with port K and a comparatively restricted exhaust of the brake cylinder air takes place while the train is at its highest speed. The area of exhaust gradually increases, however, as the pressure on piston B becomes less and the spring slowly moves the slide valve upwards in a degree proportional with the reduction of speed of the train, until it finally closes it and the desired pressure is retained in the brake cylinder until released in the ordinary manner. In performing this function, air in a large volume is discharged into the brake cylinder from both the auxiliary reservoir and train pipe through openings largely in excess of the area of ports J and K, which latter are consequently unable to discharge it to the atmosphere with equal rapidity, enabling piston B to be quickly driven throughout its entire possible traverse and the apex of port J presented to port K, giving an area through which the excess air is slowly discharged to the atmosphere, but gradually increasing in a required degree as the piston and slide valve ascend to their normally closed position.

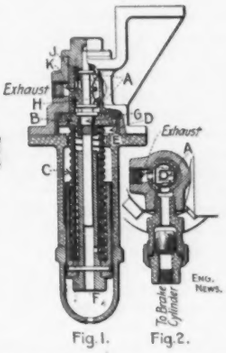


Fig.1. Fig.2.

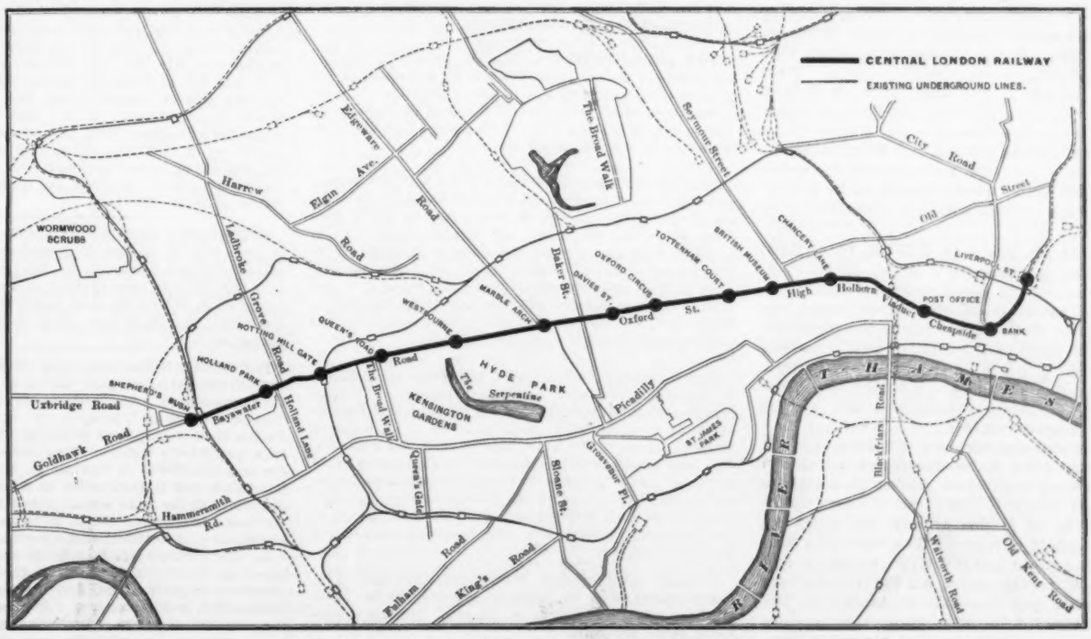
In our issue of April 12, 1894, we gave an account of a comparative test of the quick-action and high-speed brakes made on the Pennsylvania R. R., but since that time the apparatus has been considerably improved. The high-speed brake has been in use on the Empire State express of the New York Central R. R. for about three years, and is also in use on the Congressional Limited express of the Pennsylvania R. R.

A description of this high-speed brake has been prepared for publication and will shortly be issued by the Westinghouse Air Brake Co. of Pittsburg, Pa. We are indebted to an advance copy of this for the information from which the present article is prepared.

THE CENTRAL LONDON RAILWAY.

London has always been the centre of underground passenger railways, and bids fair to maintain this distinction for some time to come. This results from the impossibility of surface railways in the crowded portions. The demand for rapid transit and the narrow crowded streets were early responsible for the introduction of underground steam roads, and the well-known City and South London road was the first electric underground passenger railway in the world.

As our readers know, since the completion of the City and South London Ry. various electric underground railway schemes have been under consideration in London. One of these, the Central London Ry., was taken up some time ago by American capitalists, and has been rapidly pushed forward. The contract for the entire electric equipment has been let to the British Thomson-Houston Co., representing in Great Britain the



MAP SHOWING ROUTE OF THE CENTRAL LONDON RAILWAY.

General Electric Co., of Schenectady, N. Y., and we are indebted to the General Electric Co. for the information below concerning the road and its equipment. It may be remarked that the contract for the elevators which will be used at the stations on the line has been given to an American firm, the Sprague Electric Elevator Co., of New York.

Location.—The tunnels, two in number, start from the Great Eastern Ry. Co.'s Station and the city terminus of the North London R. R., as well as the Bishopgate St. Station of the Metropolitan Underground Ry. (see cut), and proceed almost in a straight line due west, under the busiest part of the city, to Shepard's Bush, a distance of 6½ miles. Fourteen stations, including the terminals, are to be constructed, which will afford convenient stops while permitting a fair speed. The tunnels are very deep, the distance below the surface being at some points betweeen 70 and 80 ft.

An ingenious method, which will save about 35% of the power necessary to accelerate the trains, will be employed to assist in stopping and starting. This in brief consists in giving the tunnels a down grade on the departing side of each station, and a rise on the approach, of 3% in each case. In this way the gravity will be utilized with a large saving to the generating station.

The east and west bound tunnels have a diameter of 11½ ft. inside the lining. In driving the headings and placing the sheets Greathead shields, 12⅔ ft. in diameter, were used. These were forced forward into the clay soil by six hydraulic jacks of a combined power of 230 tons.

Track.—This will consist of 100-lb. steel rails laid on heavy cross ties and well ballasted. A third rail will carry the electric current, and will be supplied with ample copper feeders, with frequent taps, all controlled from the signal stations so that the operators can cut out any section desired. The trains will be drawn by electric locomotives taking current from this rail, and the schedule speed, including stops of 20 seconds at each of the 14 stations, will be 14½ miles per hour. This will necessitate rapid acceleration and effective braking power.

Generating Plant.—The power station will be built above ground at Shepard's Bush, the western terminal of the road.

Six 1,300-HP. horizontal Corliss engines, built by the E. P. Allis Co., of Milwaukee, Wis., will be supplied with steam from a battery of Babcock & Wilcox water-tube boilers, and will drive six direct-connected General Electric three-phase generators, supplying current at 5,000 volts. These generators belong to the latest type of General Electric polyphase machinery, and form an excellent example of up-to-date electrical design. They are what is known as the rotating field, stationary armature type; each will have a capacity of 850 K-W. at 5,000 volts, when running at 94 revolutions per minute, which will give a periodicity of 25 cycles.

Heavy leads will carry the 5,100 K-W. of 6,800 HP. of the six machines to a switch board, from which feeders convey the three-phase current to the various sub-stations distributed along the line. In these, static transformers will drop the pressure from 5,000 to 330 volts, or that necessary for the alternating side of the rotary converters. The working line voltage given out by the direct current side of these transformers will be the usual R. R. pressure of 500.

Of the four sub-stations, two will contain seven 300 K-W. step down static transformers, and two 900 K-W. rotary converters similar in design to those used at Niagara. Only six of these transformers are to be in use at any one time, the seventh being held in reserve. The remaining sub-stations will contain one 900 K-W. converter and four 300 K-W. transformers. All the transformers to be installed will be what is known as the "air blast type." In this style the winding and core-plates are so placed that air under pressure, from some suitable blower, can circulate freely about the parts and thus conduct away the energy wasted in C^2R, hysteresis and eddy currents. The object in using this method of transmission is to centralize engines, boilers and generators and reduce losses in line conductors by employing a high voltage. Otherwise the copper loss due to the large currents demanded by the locomotives would be enormous. Again, by this means a very close pressure regulation can be maintained, and this is an essential feature in an underground system, where lighting must play such an important part. It is confidently expected to regulate within 3 volts throughout the entire plant.

Locomotives.—The construction of the 35 locomotives will follow closely the successful designs employed on the Baltimore & Ohio. Each of the engines will contain in its sheet iron cab a series parallel magnetic blow-out controller, air-brake pump and pump controller, instruments, sand-box, etc. The motors, four in number, will be what is known as G. E. 56, and will be mounted one upon each axle, directly connected. Each locomotive will weigh 35 long tons, and will have a draw bar pull of 14,000 lbs.

Elevators.—Powerful high speed Sprague elevators will be employed throughout to afford necessary egress to stations. Each will have a speed of 150 ft. per minute and a capacity of 15,000 lbs., which is equal to about 100 passengers. As there are to be 49 of these lifts, 4,900 people can be moved per minute. This complete system, it is estimated, will carry something like 48,000,000 passengers per year.

THE RENTAL SYSTEM OF RAISING MONEY for sewerage purposes is to be tried in Boston, a legislative statute to this end just having gone into effect. Under the new plan the mayor and street commissioner may expend not over $1,000,000 annually for sewerage construction and maintenance, raising the money by loans outside of the debt limit. Annual charges are to be levied against "estates" for the payment of the indebtedness incurred, benefits and previous payments for sewers on the assessment plan being considered. In other words, the cost of providing sewerage facilities is to be raised by yearly rentals, much as in the case of water-works. The experience of Boston under this system will be watched with interest.

THE MOON ISLAND SEWAGE STORAGE BASINS of the Boston sewerage system will probably be doubled in size, as the sewer division of the street department intends to increase their capacity this year from 25,000,000 to 50,000,000 gallons. Improvements are also contemplated at the Calf Pasture pumping station of the sewerage works, where it is proposed to put in iron floors and galleries and change the valve motion of the pumping engines so as to increase their duty 25%. We are indebted for the above information to Mr. Benj. Wells, Superintendent of Streets, and Mr. C. R. Cutter, Deputy Superintendent of the Sewer Division of the Street Department.

THE ACT CREATING THE NEW ORLEANS DRAINAGE Board is declared constitutional by a decision of the Supreme Court of Louisiana, issued on June 21. This decision removes all difficulty in the way of progress of the board, and allows the work to be pushed forward. The bids now in will be opened on July 8.

THE OKEFENOKEE SWAMP RECLAMATION project has failed and a receiver has been appointed for the company, according to an Atlanta news item. In 1891 a company was organized by the late Mr. Henry Jackson to purchase this swamp from the State of Georgia for 26 cts. per acre, the total cost being $63,101. The company went to work upon its reclamation scheme and it is said that as much as $540,000 has been expended. Inability to dispose of its lumber product and general hard times are said to have caused the collapse.

THE GARBAGE CREMATORY AT NEW BRIGHTON, N. Y., has been declared "a private nuisance" as "heretofore conducted" and the village has been enjoined from so operating it in the future as to give rise to "stenches or offensive odors." The court also awarded the plaintiffs, who were residents in the vicinity of the crematory, $157 damages. No information is at hand to indicate whether the nuisance has arisen from improper design and construction or from ignorance or carelessess in operation. The crematory, as built two years or so ago, was of the Brownlee type.

STREET SPRINKLING WITH DISINFECTANTS is under consideration in Brussels, according to Mr. Geo. W. Roosevelt, U. S. Consul to that city. Creoline is preferred as an antiseptic.

EXPANDED METAL IN THE CONCRETE FOUNDATION for asphalt pavement in Chicago is said to be called for by recent specifications. The concrete base will be only 4 ins. thick, instead of the 6 or 8 ins. usually required.

A SUSPENSION BRIDGE OF FENCE WIRE and boards has recently been constructed across the Waukarusa River in Douglass county, Kansas, which, if the press reports of its dimensions are correct, speaks well for the cool nerves of Kansas school children not to mention the audacity of its designer. It appears that the Waukarusa, like many other Kansas rivers, has the trick of swelling from a mere rill to a torrent of very respectable dimensions at every rainfall, causing an enforced absence from school of the children living across the stream from the school house. The county engineer was called upon to remedy the trouble and this is the way he did it, according to the Kansas City, Mo., "Star:"

He bought quantities of fence wire, boards and timber, and within two weeks constructed a viaduct as novel as it is useful. The piers on each side of the bank were made of good sized oak logs. Strips of board 3 ft. long were fastened together with wire and over these strips was run a plank walk 2 ft. wide. Each end of the superstructure was then anchored to the piers. Sides consisting of a network of wire were then put up and the problem of bridging the Waukarusa was solved. The bridge is 200 ft. long and 60 ft. from the water.

THE CONGRESS OF THE INTERNATIONAL Association for the Testing of Materials of Construction will be held at Stockholm on Aug. 23-25 inclusive. Aside from the reception of reports of committees and official business, the following papers will be presented: "The development of the industry of materials of construction in Sweden and their methods of test," by C. A. Dellwik, Director of the Bureau of Metallurgy, at Stockholm; "Microscopic metallurgy as a method of testing," by F. Osmond, C. E., of Paris; "Report upon the ways and means of introducing uniform international rules for determining the quality and testing and accepting all classes of iron and steel," by Mr. Ast, Royal Director of the Northern Railway, Vienna; a request presented by M. Polonceau, Chief Engineer, Paris-Orleans Ry. Co., that a commission be named to submit to the next congress an adjustment of the differences existing between the resolutions adopted by the international congresses at Munich, Dresden, Berlin, Vienna and Zurich, and the conclusions of the French Commission; and a report on the actual status of the question of international siderochemical laboratories, by Dr. Wedding, of Berlin. There will be excursions to the industrial expositions and on the harbor, and several official dinners, reunions, etc.

THE DECIMAL SYSTEM in engineering measurement was the subject of a paper read by Capt. Sankey before the Institution of Civil Engineers on May 27. Capt. Sankey favored the metric system; said that the changes in gages and templates would be less expensive than was usually charged, and that the only difficulty he found was in connection with screw threads. In the works with which he was connected the metric system was introduced in 1893, and no difficulty was experienced in getting draftsmen to use the new measures and few minor and no serious mistakes were traceable to this cause. All the draftsmen now favor the metric system as being easier to work with and to check. The discussion of the paper was about equally divided between those who favored the metric system and those who preferred the inch decimally divided as a unit. Mr. Alex. Siemens pointed out the fact that only 10% of England's foreign trade was done with her own colonies, while 90% was with nations demanding metric measurements. He said that the metric system originated with James Watt, who proposed an international conference in 1789. All the English manufacturers who had changed to the metric system were led to do by purely commercial reasons, and they had profited by the change, according to the discussion.

THE MEXICO, CUERNAVACA AND PACIFIC RY. will be completed to the city of Cuernavaca in a few weeks, about 5,000 men being now employed on its construction. This line will run from the City of Mexico to the port of Acapulco, on the Pacific coast, and will be the first transcontinental line in Mexico, north of the Isthmus of Tehuantepec.

THE SIEMENS-HALSKE ELECTRIC CO., of Chicago, and the Pennsylvania Iron Works Co., of Philadelphia, have consolidated. The directors are: Messrs. Charles E. Yerkes, William L. Elkins, Jr., B. W. Grist, Charles T. Yerkes, R. S. Grant, F. W. Whitridge, W. T. Butler, E. L. Rice, and Martin Maloney. The Siemens-Halske Electric Co. was established in Chicago at the close of the late Exposition, and is an offshoot of the Berlin and London companies of the same name. It bought out the plant of the Grant Locomotive Works, in Chicago, and began the manufacture of electrical machinery under the Berlin patents. The Pennsylvania Iron Works are owned by what is known as the Philadelphia Street Car Syndicate, and it manufactures cable railway plants, gas and steam engines, refrigerating machinery, etc. The capital stock of the company formed by the consolidation is $3,250,000, and it is now prepared to completely equip street railways with either cable or electric machinery.

THE POPULATION OF RUSSIA, according to a government census brought down to Jan. 1, 1897, is 129,211,113, with males and females almost exactly equal in numbers. This is an increase of 61,830,463 over the population of 1851. But since that date Russia has acquired control over Central Asia, and is now developing along the line of the Siberian Railway.